POWER

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Industrial Democracy

IN talking with the Commissioner of Public Works of one of the States during a period of depression, an Italian contractor picturesquely described the increased willingness of labor to do a full day's work as follows:

> Today I say to the workman, "You take that pick and dig or I smash your head!" Before, when I tell him to go to work, he say, "You shut up or I smash your head!"

Here is the labor trouble in a nutshell.

Labor, even unskilled "common" labor, has attained some sort of dignity and self respect and "On the forehead of his brother no man writeth slave," not even an Italian contractor.

It is this assumption of autocratic authority more or less manifest on the part of a happily diminishing number of employers of labor that arouses natural resentment and a determination on the part of the subject to do some head-smashing on his own account when the tables are turned.

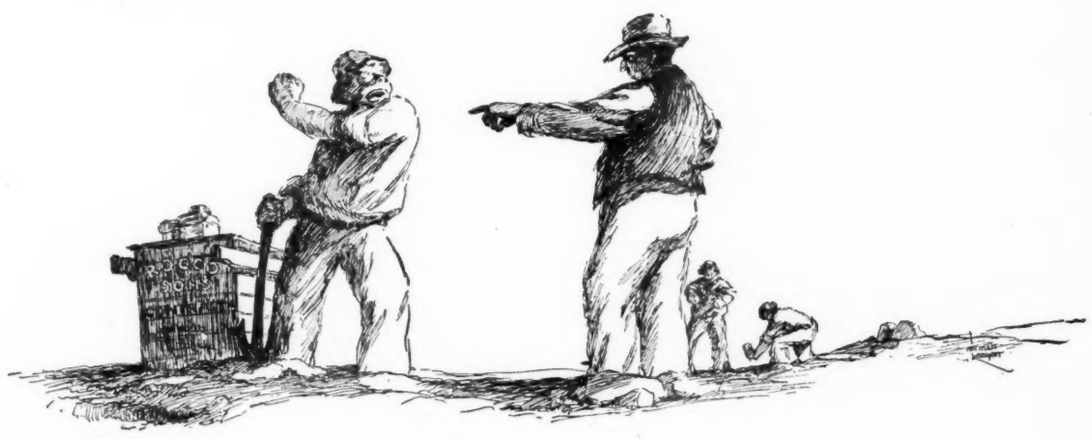
And, withal, a determination to do his damndest, by fair means or foul, to turn those tables at the first opportunity.

In the democratization of industry there is no place for lord and subject, for master and slave, for domination and servility or for insubordination and mutiny.

If there had to be an autocracy, I would rather be ordered by the Autocrat of the Breakfast Table than by the Autocrat of the Pick.

In a peaceful army organized for the most efficient and effective performance of the labor of the world, there must be order and discipline. All cannot be generals and captains. But there can be courtesy and consideration and fellowship, a realization of the common purpose, and an acknowledgment of the fact that each in his particular sphere is essential to the proper functioning of the whole.

F. R. Low



Airplane view of Shawinigan Falls development

Hydro-Electric Power Developments at Shawinigan Falls, Quebec

QUEBEC is one of four Canadian provinces that are richly endowed with water power. It is estimated that the total water powers of this province amount to about 5,250,000 kw. for continuous 24-hour use, of which 800,000 kw. has been developed. These power sites for the most part are on the four great river systems in the province—the St. Lawrence, the Ottawa, the Saguenay and the St. Maurice. It is on the last-named that the Shawinigan Water & Power Co. has completed developments totaling 242,000 hp.[1] at Shawinigan Falls, and has under way a 175,000-hp. development at La Gabelle (Gres Falls), about seven miles below Shawinigan. It is expected that at least four 35,000-hp. units will be in operation in this plant by the end of this year. In addition to this the company controls the operation of the Laurentide Power Co.'s plant at Grand Mere Falls, about seven miles above Shawinigan. This plant has a present capacity of 164,000 hp. At these three sites there is a possible development of over 640,000 hp., of which about 63 per cent has been developed and is in operation.

[1]Includes 45,000 hydraulic horsepower sold to the Northern Aluminum Co. and Belgo Canadian Pulp & Paper Company.

DEVELOPMENTS aggregating 242,000 hp. have been completed and a 175,000-hp. project is under way by the Shawinigan Water & Power Co. Total developments will aggregate 640,000 hp., of which 400,000 hp. has been completed. The latest unit installed is a 41,000-hp. single-runner vertical-shaft turbine to operate under 145-ft. head. Previous units installed in this plant were 20,000 hp. capacity of the double-runner horizontal-shaft type. The new machine has carried a load of 49,000 hp. and is exceeded in capacity only by the Niagara Falls Power Co.'s new units and those installed at Queenston. The penstock is cut in solid rock, is 20 ft. in diameter inside the concrete lining and has a specially designed intake terminating in a gathering tube.

The St. Maurice River is one of the largest in Canada and has its source in the divide between the Hudson Bay and St. Lawrence drainage systems. It has a length of about 300 miles and flows into the St. Lawrence at Three Rivers about halfway between Montreal and Quebec City (see Fig. 1). On this river system the provincial government has constructed four regulating dams. The most important of these is the Gouin dam, about 200 miles above Shawinigan Falls. This dam is 1,800 ft. long and 70 ft. high and forms a lake 360 square miles in area, making it the largest artificial storage reservoir in the world. When full, this reservoir contains water enough to generate one billion kilowatt-hours in the plants at Grand Mere, Shawinigan and La Gabelle. Three other storage reservoirs have been created on the Manouan River, a tributary to the St. Maurice, and these have a combined capacity of about 400,000 acre-feet. At the Grand Mere power development the dam backs water up the river about 20 miles and forms a reservoir of about 22,500 acre-feet. The head on this plant is 85 ft., and it contains six 20,000- and two 22,000-hp. units. At Shawinigan Falls the

dam backs the water up to Grand Mere and makes possible a head of 150 ft. at this site. When the plant is completed at La Gabelle, it will provide a head of 65 ft. and will raise the tailwater level at Shawinigan Falls Plant about two feet.

In making the development at Shawinigan Falls, a dam was built across the crest of the falls and the water

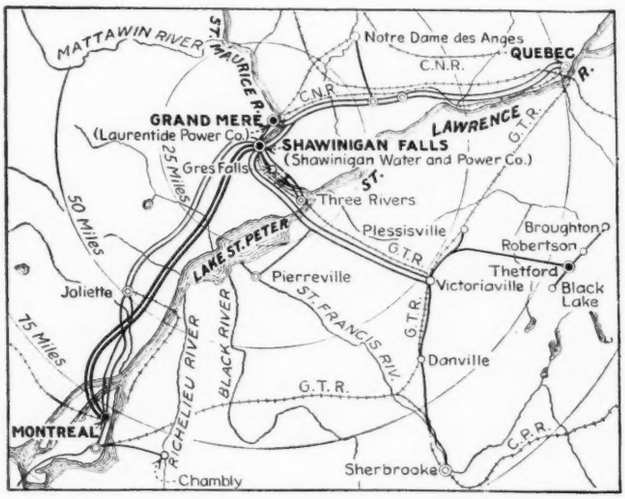


Fig. 1—General layout of Shawinigan Water & Power Co.'s developments

deflected through a canal one mile long to a forebay at the top of the bank near where the Shawinigan River flows into the St. Maurice (see headpiece). All power plants are supplied through penstocks from this forebay. As plant extensions have been made, the forebay and headworks have been increased to meet the new requirements.

Shawinigan Falls Power Plants

There are two power plants at Shawinigan Falls owned and operated by the Shawinigan Power & Water Co. These plants can be seen at *A* and *B*, in the headpiece. The first installation was made in 1902, consisting of two 5,000-hp. wheels in what is now known as station No. 1, shown at *A*. This plant was completed in 1911, when the station reached a capacity of 58,500 hp. and the largest unit installed had a capacity of 11,500 hp. In plant No. 1 power is generated at 30 cycles, but when the designs for plant No. 2 were laid down in 1910, it was considered advisable to go to 60-cycle power in this plant, as this would be more satisfactory for the new power contracts obtained by the company.

Plant No. 2 as originally laid out contained five 20,000-hp. horizontal-shaft double-runner turbines of the Francis type directly connected to 15,000-kva. 6,600-volt generators operating at 225 r.p.m. These machines were each supplied through a steel penstock 14 ft. in diameter which branched in the power house to supply the two turbines comprising a unit. A bent draft tube serves each pair of turbines, which are of the center discharge type. In construction this plant is typical of a number of important stations built during the same period; the turbines are in one room with the shaft extending through the wall to the generators in another room. The leads from each generator go to a bus and then to a bank of transformers. Normally the buses are sectionalized and each generator and bank of transformers operate as a unit, being parallel on the high-extension side of the transformers.

The latest addition to plant No. 2 is a 41,000-hp. unit of the vertical-shaft type which marks the transition from the horizontal-shaft to the vertical-shaft arrangement, as all the previous units in the other plants of the company are of the horizontal type. As previously indicated, the first units installed in 1903 were of 5,000 hp. capacity and were the largest that could be constructed at that time. This new unit is over eight times the rated capacity and has carried almost ten times the load, or 49,000 horsepower.

In 1910, when the design of plant No. 2 was laid down, the 20,000-hp. horizontal-shaft units of the double-runner type were adopted and these were among the largest machines built at that time. It was considered then that this would be the type of machine used to complete the development, but in 1920, when it was decided to extend this plant, the vertical-shaft type was chosen, this type having been developed to where it had a number of advantages over the horizontal-shaft type. The vertical-shaft type can be designed for a somewhat high efficiency. It requires less space and construction material, and the problem of the thrust bearing has been solved by two different types. For the 20,000-hp. horizontal-shaft units the spacing is 40-ft. centers; it will be 60-ft. for the three 41,000-hp. vertical-shaft units that will be ultimately installed to complete this development. The machine now installed is set in an extension of the original turbine room which affords ample space. The generator room has been ex-

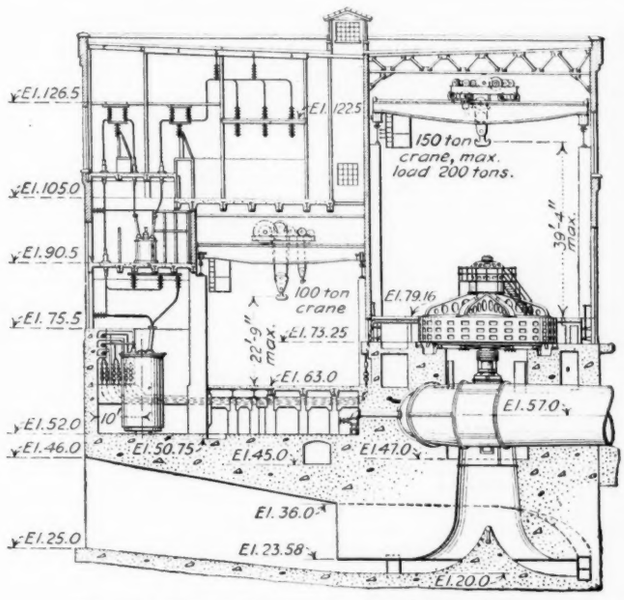


Fig. 2—Power-house cross-section through 41,000 hp. unit

tended, but this is to maintain uniformity of construction in the station and to allow extending the crane runway.

Water for the 41,000-hp. unit now installed, which requires 3,000 cu.ft.-sec., is taken through the same canal that supplies all the other machines. This was found possible to do and increase the flow to only about 3.25 ft. per sec. in the canal, which is 130 ft. wide and 35 ft. deep. The forebay and gatehouse were extended

80 ft. to accommodate the additional capacity, the extension conforming to the present structure. These extensions are made to the right of plant *B* in the headpiece. The intake to the penstock, which is 74 ft. wide, is divided into five sections 12 ft. wide with pier 3 ft. 6 in. thick between them. In these piers are slots for gates, racks and stop logs and as the spacing between the piers is the same as for the other units, the same stop logs can be used.

Provisions are made in the gatehouse for heating the racks with hot air. Considerable trouble in the past has been experienced with ice forming on the rack into the end of the penstock and the other four through nearly rectangular openings in the side, as indicated in Fig. 3. The upstream end of the penstock tapers toward the intake from the normal diameter of 20 ft. to 13 ft. 4 in. at the beginning of the round section. This tapered section forms a so-called gathering tube. In this tube the water is gradually accelerated from about 2 ft. per sec. between the intake pier to 10 ft. per sec. in the penstock. A loss of head of 4.75 in. with a 3,000-sec.-ft. flow is estimated as occurring in the gathering tube. This is considered to be the most economical when the complication in the design and

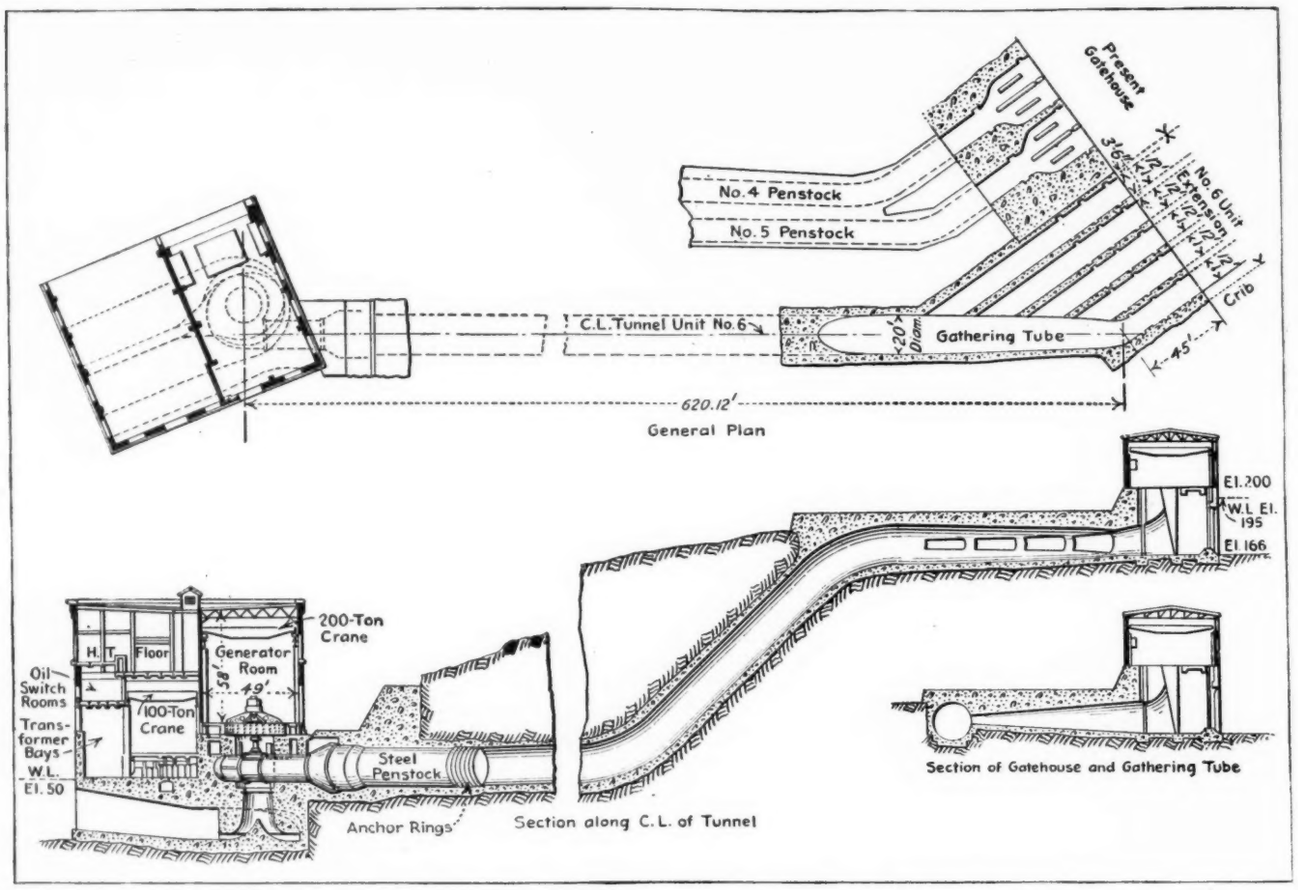


Fig. 3—Water enters the penstock through five specially constructed passageways

bars. A large air duct is formed in the gatehouse floor from this main duct; lateral ducts lead to the entrance of the penstocks so that the air can be blown on the racks. A fan having a capacity of 60,000 cu.ft. of free air per minute is located at one end of the gatehouse. The air is drawn into the fan through electric heaters and its temperature raised to about 150 deg. F. and then discharged into the main air duct. Since the installation of this system no trouble has been experienced with either the racks or gates.

One of the most interesting features of the installation is the design of the penstock intake. The problem involved was to get an approximately equal flow in all parts of an intake 30x74 ft., into a circular penstock 20 ft. in diameter. The problem was complicated by the fact that the intakes from the forebay were at a 35-deg. angle to the penstock, but it was successfully solved by leading one of the five water passages directly additional cost necessary to affect a material reduction in the value were estimated.

A test made on a model showed that this type of intake will give equal distribution of flow, but the dimensions have to be carefully determined as a small change will cause unequal flow in the different intakes passages. The design of this intake was worked out by Messrs. R. D. Johnson and P. Wahlman, of New York City.

Steel penstocks are used to connect the 20,000-hp. horizontal-shaft turbines to the forebay. When considering the type of penstock for the 41,000-hp. vertical-shaft unit, it was found to be more economical both in construction and maintenance costs to use a concrete-lined tunnel cut in the rock cliff between the power house and forebay. This tunnel is 24 ft. inside diameter and has a reinforced-concrete lining about 2 ft. thick, giving a finished inside diameter of 20 ft. At

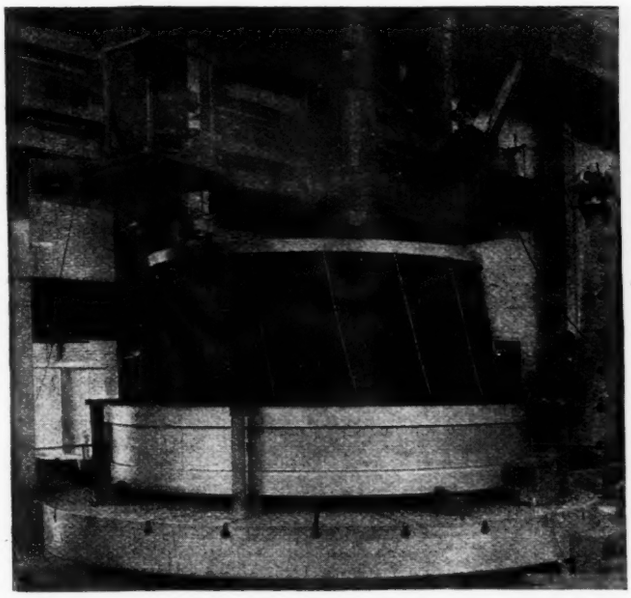


Fig. 4—Runner for 41,000-hp. turbine on boring mill in the machine shop

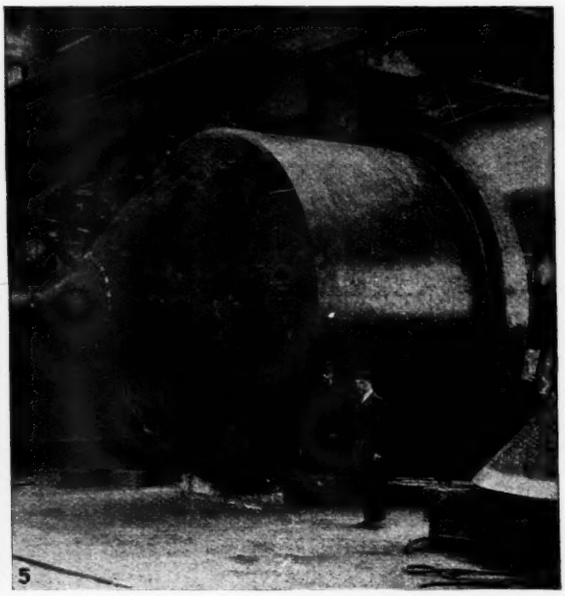


Fig. 5—Plunger of Johnson penstock valve

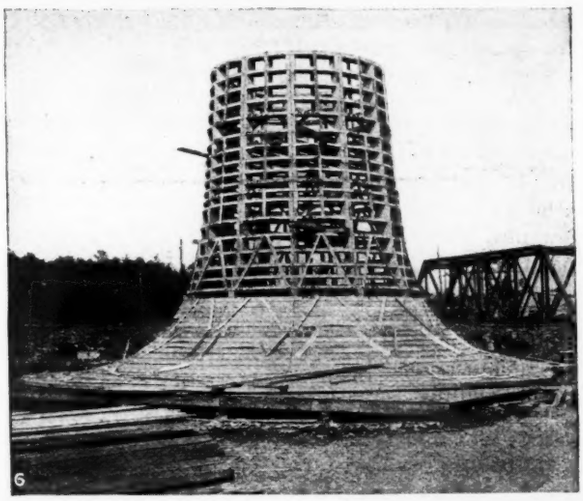


Fig. 6—Draft-tube form under construction

Fig. 7—Cast-steel turbine volute casing assembled on foundation in power house

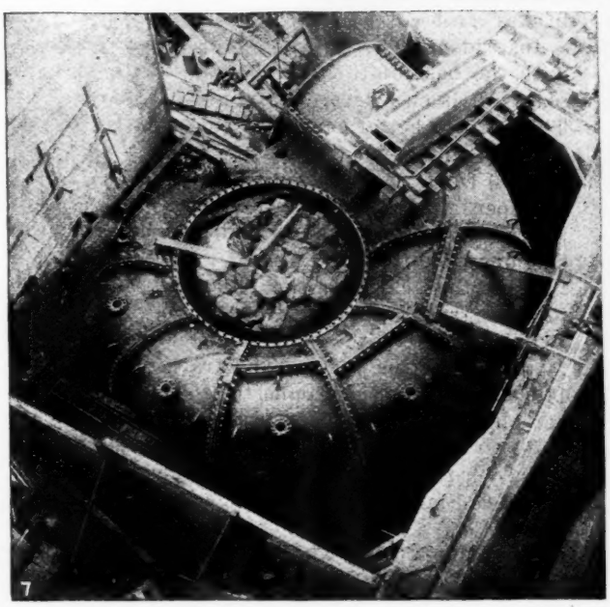


Fig. 8—Inside of penstock, which is 20 ft. in diameter inside of concrete lining

the lower end it connects to a needle-type valve by a steel-plate penstock 77 ft. long by 20 ft. diameter. This section is built of plates 1¼ in. thick and is anchored into the tunnel by 7 rings, riveted to the plates, made of 4x4x½-in. angle iron, which also serves to prevent leakage along the connection between the steel-plate section and concrete lining.

In designing the penstock, it was estimated that the worst surges that might be expected to obtain would increase the static head to about 300 ft., or a pressure of about 130 lb. per sq.in. It is to withstand this bursting pressure that the steel section of the penstock and the lower end of the concrete lining was designed. The cost of constructing the tunnel section complete was about $370 per ft. against about $450 per ft. for the steel-plate section. It is estimated that the loss of head in the penstock, including that in the gathering tube at its upper end, will be about 1.1 feet.

A Johnson valve forms the connection between the steel-plate penstock and the turbine spiral casing. This valve is 20 ft. in diameter at the intake and 13 ft. at the discharge, with a maximum diameter of 23 ft., and is 27 ft. long. The total weight is about 150 tons, with 25 tons of this in the moving part. This valve is exceeded in size only by the three being installed at Niagara Falls, one of which went into service recently. As can be seen from Fig. 3, the penstock valve is located outside the power house. The control is so arranged that the valve may be operated from the generator control board or from the valve chamber.

The older section of the power house is 115 ft. wide by 75 ft. high, and on account of uniformity these dimensions were adopted for the extension to house the new unit. However, the new unit complete, which has more than double the capacity of the older machines, is installed in the extension of the turbine room for the latter, the extension of the generator rooms not being required. The generator floor of the new machine will be 16 ft. above the turbine-room floor of the older machines. To facilitate handling the parts of the new unit, a 200-ton crane is installed.

Draft Tube Construction

On account of the size of the unit and the loads, over 12,000,000 lb. that had to be supported, the draft tube, which is of the Moody spreading type, offered a difficult problem. The draft-tube chamber is of horseshoe shape 52 ft. in diameter and 48 ft. between the points. The draft-tube bell is hung from the under side of a reinforced-concrete slab 12 ft. thick. The upper section of the draft tube just below the turbine casing is of cast iron surrounded by a passage for access to lubricating piping for the lower guide-vane bearings and to the manholes for entering the draft tube. Fig. 6 shows the inside form of the draft tube and gives some idea of its dimensions.

The turbine, which was built by the Dominion Engineering Works, Ltd., is designed to operate under a normal effective head of 145 ft. at a speed of 138.5 r.p.m. The specific speed is therefore 56 in the foot-pound system, or 248 metric. The turbine is of the single-runner vertical-shaft type, the runner being of normal design of the usual mixed-flow, or so-called "Francis" type. It is designed for a normal rating of 41,000 hp., but in actual operation this unit has developed 49,000 hp. at full-gate. In relative capacity, therefore, it ranks among the most powerful turbines so far built, being exceeded only by the 55,000-hp. units in the Queenston plant of the Hydro-Electric Power Commission of Ontario and the 70,000-hp. units now being built for the Niagara Falls Power Co.'s station No. 3C extension, one of which went into operation Dec. 18, 1923.

The turbine casing is of volute form and is of cast steel divided into a series of radial sections, the larger ones being further divided into outer and inner portions, so that the stay-vanes can be cast as a part of the sections. It contains no stay-vane ring, or so-called "speed-ring," but has the stay-vanes cast integrally with the casing sections. The casing construction is thus considerably simplified and a saving in weight effected, while at the same time greater rigidity and tightness are secured. The intake diameter of the casing is 14 ft. and is believed to be exceeded only by those for the new Niagara turbines.

Generator Designed to Operate at 75 per Cent Power Factor

The generator was purchased from the Canadian General Electric Co., but was built at Schenectady, N. Y. It is rated at 11,000 volts 60 cycles 30,000 kw. at 75 per cent power factor, or 40,000 kva. In designing this machine its characteristics have been made such that the instantaneous short-circuit current will be only 3.3 times full load and the sustained short-circuit current will be equal to twice full-load current at normal full-load excitation. The rotor spider consists of six cast-steel wheels divided into halves. This allows of easy assembly, and when the two halves of each wheel are in place on the shaft, they are drawn together by bolts which are shrunk in place. The 52 polepieces are dovetailed to the spider and secured by wedges. To reduce windage losses, the spokes of the rotor are encased with steel plates. A thrust bearing of the G. E. spring type is mounted above the generator's stator frame and supports the entire weight of the revolving element, which weighs 725,000 lb., including the downward thrust of the water. Provisions are made for bringing the rotating element to rest by oil- and air-actuated brakes applied to the under side of the rotor. Air pressure at 200 lb. per sq.in. is required to operate the brakes, and a separate oil-pressure pump is provided so that the brakes can be used as lifting jacks to raise the rotor.

Instead of the operating-room floor being on a level with the base of the generator, as is the case in most plants, it is on a level with the top of the stator frame. This gives a better control of the cooling air and makes it much quieter on the operating floor. Approximately 100,000 cu.ft. of cooling air passes through the generator per minute. This air is drawn from the wheel pit through radial tunnels and may be discharged outside or inside the building.

From the generator the 11,000-volt leads go directly to the transformers without any intermediate oil switch, although disconnect switches are provided to facilitate making tests. The transformers step up to 110,000 volts and are connected to the high-tension busbars by two oil switches placed in separate chambers.

Power wishes to acknowledge the assistance and co-operation rendered in the preparation of this article by Julian C. Smith, general manager, Shawinigan Water & Power Co.; S. Svenningson, chief engineer, Shawinigan Engineering Co.; Lewis F. Moody, consulting engineer, William Cramp & Sons Ship and Engine Building Co.; and H. S. Van Patten, hydraulic engineer, Dominion Engineer Works, Limited.

Maintaining Quality of Steam Turbine Oils in Service

By CHARLES H. BROMLEY*

FROM the viewpoint of the engineer the basic essential in an oil is durability. It must reliably perform its functions of lubricant and coolant over long periods with minimum waste when continuously cleaned by methods that keep out the soluble and insoluble sludge, organic acidity, solids, water and emulsion, and that do not promote oxidation. It is not uncommon for turbines to run three to four weeks without shutdown. Some run continuously for months. To have to shut down a large, high-economy unit because of lubricating oil trouble and carry the load on smaller, comparatively uneconomical units, will cost an operating company many thousands of dollars a year.

Steam-turbine service conditions are severe upon oils. Steam temperatures (total) of 600 deg. F. and even higher at the throttle are common. The high-pressure end bearing is subjected to considerable of this intense heat. In an 1,800-r.p.m. turbine with shaft, say, 8 in. in diameter, and the turbine running 21 days continuously each month, the oil in each bearing is rubbed, at bearing pressure and temperature, more than 110 million lineal feet.

IT is now common knowledge that for steam-turbine service there should be used none other than a "straight" mineral lubricating oil, free from organic acidity when new and closely in accordance with the specifications of the Prime Movers' Committee, National Electric Light Association, or other equally authoritative body. The oil must not be blended with cylinder stock nor with oils having the characteristics of cylinder stock or fatty acids. The containers as received must be clean, freed of sludge and acid oil and dirt before the oil is put into them for shipment. The article deals with the principal factors in the recent development of information and equipment as related to maintaining the quality of lubricating oils in use in steam turbines.

It would be well at the outset to call attention to the fact that power-plant engineers are inclined to expect too much of an oil as related to its durability. Not that it is a good thing to seek oils of great durability, but unfortunately, engineers do not seem to appreciate adequately that in a petroleum lubricating oil we have one of the most complex hydrocarbon compounds known to science, and susceptible in marked degree to the influences of heat, air (oxygen), light and pressure. The power-plant engineer is accustomed to dealing with products about which the characteristics are quite fully known. If he does not know or remember the characteristics of such things as water, fuels, ammonia, air, electricity and other products with which he daily deals, he can turn to his handbook and there find how they will behave under all ordinary conditions. This is not true of petroleum lubricating oils to anywhere near the same degree of accuracy. The average engineer does not fully enough appreciate this fact, and in his lack of appreciation of it he is more than likely to think these oils are more stable than they are and that the behavior of lubricating oils under definite conditions is as well known as are the characteristics of other products familiar to him. He therefore expects too much of petroleum oils and petroleum technologists.

Dr. W. F. Farager, Mellon Institute of Industrial Research, very well expresses the situation when he says: "Our knowledge of the chemistry of the substance present in the higher-boiling fractions of petroleum is so incomplete that it is impossible to state the case of the products other than gasoline and burning oil from most crude oils, even the series of hydrocarbons which are present. Very little is known, also, about the compounds of sulphur, oxygen and nitrogen existing in these higher-boiling fractions. This lack of accurate, detailed, chemical information about the constituents of lubricating oils makes it necessary to attack many of the problems of their preparation and use by wholly empirical methods."[1]

Oxidation brings about deterioration of the oil. Likely the lighter fractions are first to oxidize. Of the sequences in the chemistry of oxidation none too much is known. There is a lot of glib talk about unsaturated hydrocarbons, compounds of sulphur and other substances in connection with oxidation and the sources of sludge formation, but brass tack information is not plentiful. The writer has never seen even the names of these unsaturated hydrocarbons. However, it is generally accepted that oxidation does occur and is the reason oils "go bad" by becoming loaded with organic acidity and sludge. That is, oxidation causes organic acidity and sludge.

High temperature, as bearing temperatures go, water, rapid circulation and exposure of considerable surface of the oil to the atmospheric air—all promote oxygen absorption with consequent organic acidity and sludge. If the oil as it comes from the refiner is chemically unstable, its breakdown under these conditions is rapid. Of course no petroleum oil is absolutely chemically stable; refining is not yet so perfect. Therefore, breakdown is sure to come some time—quickly, if no attempt is made to clean the oil continuously while in service by methods that do not promote oxidation.

Ponder this term "organic acidity." In itself does it really mean much? The writer believes it does not, and will not until it is known what particular acid or acids make up this "organic acidity" and what are the chemical characteristics of each of these acids. It is well known that some oils with low organic acidity are considered more dangerous than others with comparatively high acidity content. It is said that oils from some crudes are worse than others for a given organic-acidity

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[1]Proceedings of the Engineers' Society of Western Pennsylvania, No. 10, Vol. 38, pp. 526-27.

content. Water's carbonization test is the measure of value here.

The accepted measure of organic acidity in lubricating oils is the number of milligrams of KOH (potassium hydrate) necessary to neutralize one gram of the oil. While practically all oils fresh from the stills and filters in the refineries are zero in organic acidity, this may be appreciable, when delivered to the customer, owing to unclean containers.

Organic acidity is dangerous because it promotes soluble and insoluble sludge, and this sludge in either form is serious because it will, if allowed to accumulate, stop up the oil piping, clog the cooler, also the screen on the turbine oil pump suction pipe. This latter, of course, would cut off the flow of oil to the bearings.

At what point, then, does the organic-acidity content in an oil become dangerous? There is no agreement whatsoever on this question. At what acid content is the oil likely to turn suddenly to sludge? Opinion is not in accord. Will a dangerous quantity of it suddenly turn to sludge if high enough? Opinion is that it will. Therefore every engineer's aim is to minimize the rate of acid formation by preventing oxida-

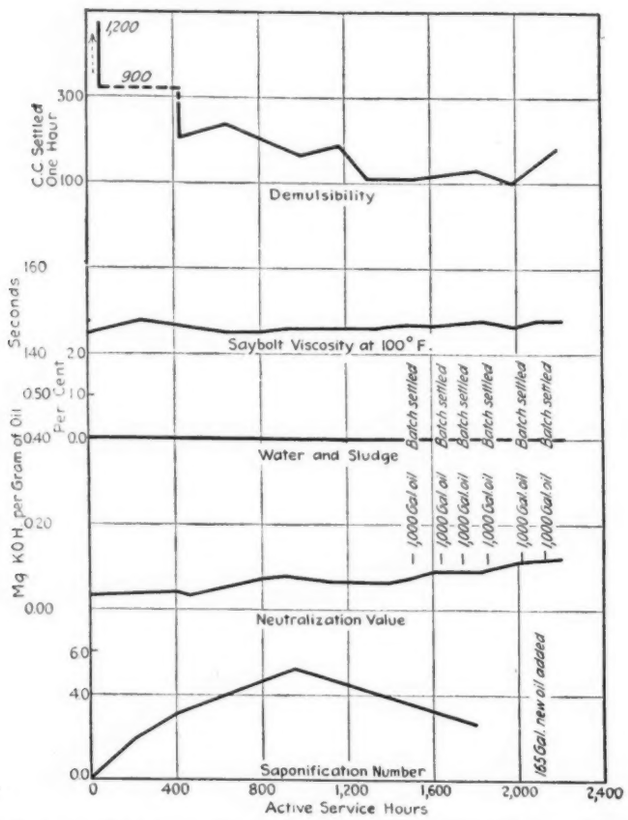

Fig. 1—Performance of continuous bypass-batch system on 60,000-kw. turbine at Colfax station

Note flatness of the water and sludge curve.

tion and by removing soluble and insoluble sludge and water and solids as fast as formed. The essential is cleanliness of the oil and the entire oiling system—reservoir, piping, tanks, cooler, screens and filter.

Behavior of oil as to demulsibility is an excellent indicator of the organic-acidity content. High-grade turbine oil has a demulsibility value[2] (Bureau of Standards) of 1,200 when new, yet within three to five hours after being put into the usual turbine reservoir and subjected to service conditions, the value drops to about 100, and usually stays there for weeks, sometimes months. If the oiling system is clean and the oil continuously cleaned by methods that avoid oxidation, it will be days, even many weeks, before the value decreases to 100. And the organic acidity rise will be

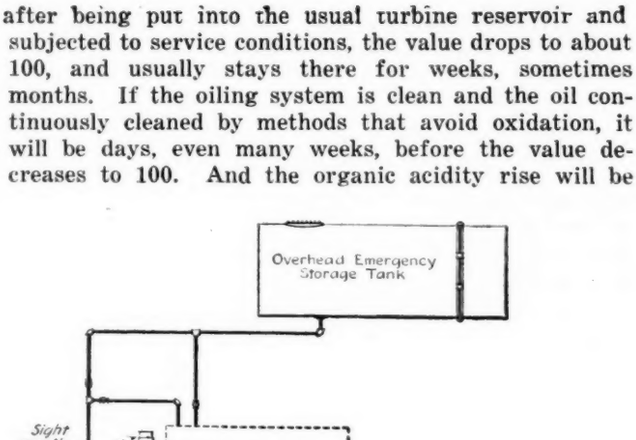

Fig. 2—Continuous bypass-batch system where only one turbine is served

At convenient intervals, about once each week if possible, all the oil in the turbine base is run into the empty compartment of the precipitation tank and allowed to settle for about a week, longer or shorter as convenient, and the clean oil in the other compartment of the tank is pumped to the turbine base.

extremely gradual. Fig. 1 shows the trend in actual service. Notice that the water and sludge curve is zero throughout the period since installation. The reason lies in a thorough avoidance of oxidizing influences both in the oil-circulating and the oil-purification systems and in the removal of both soluble and insoluble sludge. It is cleanliness without acceleration of oxidation in its accomplishment. Figs. 2 and 3 show typical layouts of the continuous bypass-batch system. Where only the continuous bypass system is desired, the precipitation tank is omitted.

Soluble Sludge

Soluble sludge is that which is soluble in the oil at the usual operating temperature of 100 deg. F. and higher. Drop the temperature of oil containing soluble sludge to, say, 80 deg. F., and the sludge will in time precipitate. Heat to 100 deg. oil containing precipitated soluble sludge, and the sludge will go back into solution. Soluble sludge is in the minds of oil chemists the beginning of insoluble sludge—insoluble sludge is the incipient stage.

"Experiments made on a 30,000-kw. turbine indicated that less insoluble sludge was found in cases where the soluble sludge was periodically removed than when it was allowed to remain in the oil," says the Prime Movers Committee, N. E. L. A. Report, 1923, page 320. This should be expected, as even the soluble sludge is considerably higher in acidity than the oil in which it is present, and as the removal of the sludge removes the acid and as acid is the "culture" that accelerates sludge formation, there is bound to be less insoluble

[2]See *Power*, March 28, 1922, p. 502.

sludge formed per unit of time than if the soluble sludge accumulated. Further, accumulation of soluble sludge is bad because when the unit is shut down and the oil and oil circulating system cool off, the sludge will drop out of solution wherever it is—in the piping, cooler and reservoir. When the turbine is again started, this sludge will be circulated as a solid for some time before it goes back into solution, and some of it will remain insoluble. It is well, therefore, not to give the oil cooler its full supply of water until the oil temperature is close to normal.

What is desired is a purification system that will, not for a month or two only, but for a period of several months, or even a year or more, keep the acidity curve as flat as the inherent chemical stability of a suitable oil permits. The acidity curve (milligrams of KOH per gram of oil) should be gradually ascending. It should not be slowly rising for but a month or so then suddenly sweep upward, as it will in any system that itself promotes oxidation. Oxidation promotes acidity, and the rate of acid formation accelerates as the acid content increases.

Effect of Heat and Air on Oil

Next to oxygen the greatest enemy of turbine oil is heat at moderate and high temperatures—from 80 deg. F. up. It is doubtful if there is a certain temperature or a certain narrow range in temperature at which

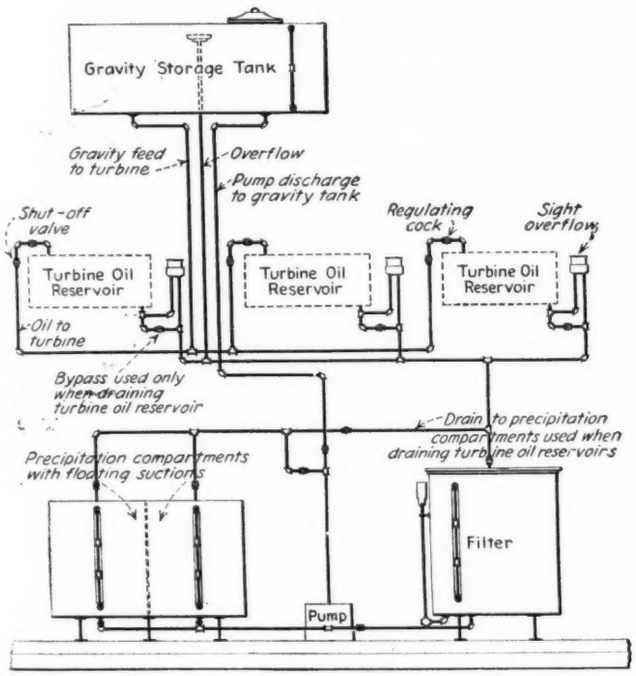

Fig. 3—Layout of continuous bypass-batch system where two or more small (500-kw. to 3,000-kw.) turbines are served by the one system

deterioration of the quality of the oil is given marked acceleration. However, experience shows that between ordinary room temperature and 100 deg. F. the effect is slow, accelerating between 100 and 140 deg. F. Between 140 and 180 deg., particularly as 180 deg. is approached, oxidation is rapid. Temperatures above 140 deg. are to be avoided when possible, and this is usually possible except for the oil delivered to the thrust bearing. Any purification system that requires the oil to be heated to high temperatures is to be avoided. The foregoing refers to oil in actual turbine service where it is subjected to pressure, water, catalytic effect of bearing metals, circulation, in addition to heat.

If oil is subjected to air while hot, oxidation is greatly augmented. Avoid exposing to the air large

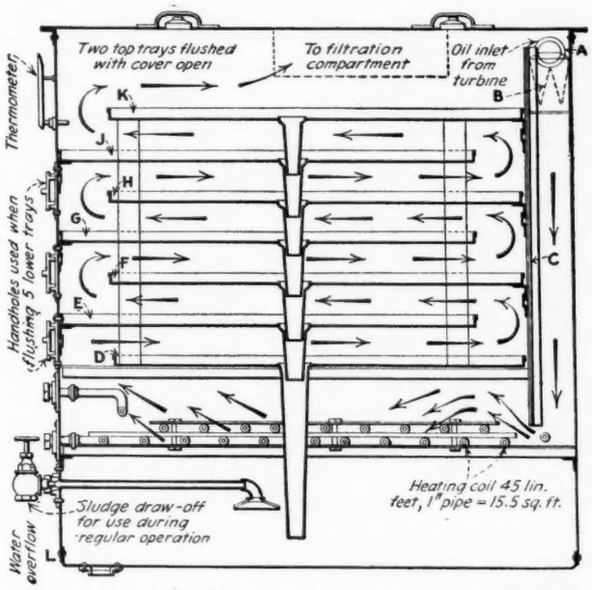

Fig. 4—Section through precipitation compartment

Oil from the turbine reservoir flows into a vented sight overflow and into the filter at *A*, Fig. 4, through 4 sq.ft. of screen *B*, down behind the curtain wall *C*, beneath the bottom tray *D*, then to and fro over trays *E*, *F*, *G*, *H*, *J* and *K*. On these trays the water, sludge and other solids drop out because of specific-gravity differences between the oil and themselves. The water and most of the sludge drop down the central interconnecting tubes in the bottom of each tray to the bottom of the filter. The water is automatically ejected at the overflow *L*. The principle is a U-tube, the oil and water mixture or oil alone, in one leg overbalancing a shorter column of water. The trays are flushed and cleaned in place by hose inserted in the handholes. Sludge may be withdrawn while the filter is in operation by opening the valve in the connection to the bottom side of the precipitation compartment. Ordinarily, the heating coil is not used, though some conditions and some oils require its use.

areas per unit of volume of the oil whether the latter is hot or cool, as then conditions are ideal for promoting oxidation. Turbine builders are now designing or have designed bearings and circulating systems that minimize the area per unit of volume of oil exposed to the air at these locations. The acidity of vapors arising from oil running into a turbine bearing in operation has been shown to be ten times as high as the acidity of the main body of the oil.

The acid content of sludge, the latter a product of oxidation, is always many times greater than the acid content of the oil in which the sludge is formed. For example, a typical analysis shows 2 mg. of KOH per gram for the sludge and but 0.44 mg. of KOH for the oil in which the sludge was formed. This accounts for the success of a purification system that keeps both soluble and insoluble sludge removed from the oil as fast as they form. It is likely that sludge has a narrow limitation of saturation in relation to acid absorption, for it is known that oils that are allowed to accumulate sludge themselves become loaded with acid. There are, however, no published data on the acid saturation limit of sludge. On the other hand, there are not any too many data on the acid saturation limits of oils, as related to the formation of sludge. One would not, however, accept without protest a new oil that showed, say, 0.2 mg. or more KOH per gram neutralization value.

and one would become alarmed if there was an increase from, say, 0.3 to 0.8 or 0.9 mg. KOH within a week or two in the oil in service. Perhaps one of the most convenient and simple ways of "keeping tabs" on the relative quality of the oil in service is daily or twice weekly to draw off representative samples from the system at a point where the oil is cleanest or supposed to be, and emulsify it with water in a malted-milk mixer such as used at soda fountains. Follow the Herschel or Bureau of Standards demulsibility-test quantities or proportions for both oil and water. Knowing the results had when the oil was new will give a good indication of how well it is holding its quality. Where a chemist is available as part of the organization, use the neutralization or Water's carbonization test.

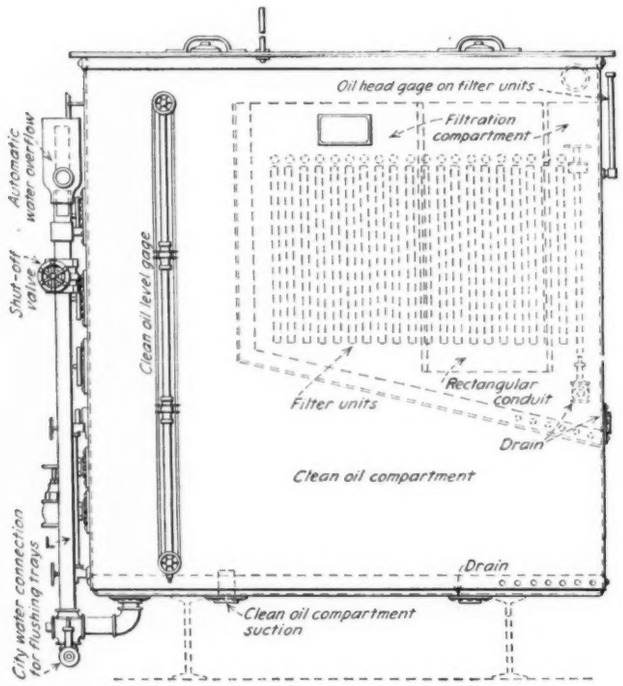

Fig. 5—Showing clean oil and filtration compartments

Typical Analysis of Sludge from Steam-Turbine Oil

The contents of sludge vary, of course, but the following is representative of Pennsylvania oils:

Material	Per Cent
Oil	18.90
Tarry Matter	14.22
Volatile	11.54
Carbon	6.56
Ash	18.64
Total	99.86

Roughly, the average insoluble sludge is about 60 per cent lubricating oil.

Recent Improvements in Oil-Filter Design

Any engineer will not have to delve deeply into the art of oil purification to become convinced that the universal practice of rating filter capacity upon the ability of a square foot of cloth to pass a given maximum volume of oil per unit of time is wrong. Such a rating will be all right for some one particular kind of service, but wholly wrong for others. For example, a filter having a capacity of, say, 1,000 gal. per hour for steam engines, would not have half that capacity for Diesel engines and nothing like a thousand gallons an hour for steam turbines. There is no interest in how many gallons can get through the filter in an hour or a day, *but how well does the filter purify the oil at any rate that is commercially satisfactory for the particular service to which the filter is being applied?* Figs. 4 and 5 show a filter that has been designed specifically for steam-turbine service and which is now in wide use.

The idea was to make available in the filter large oil volume and to have very slow velocity of the oil in its passage through the filter. Every care has been taken to avoid large area per unit of volume of oil making contact with air (oxygen) to avoid oxidation. The precipitation-tray area is 11,500 sq.in., and velocity in the precipitation compartment is well below 0.5 ft. per min.

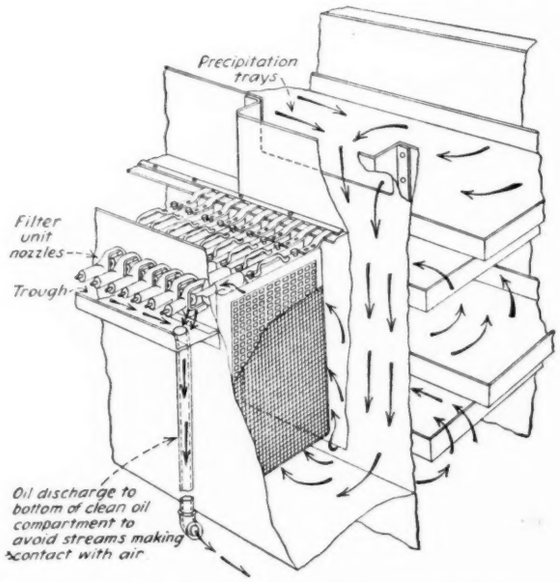
Precipitation trays
Filter unit nozzles
Trough
Oil discharge to bottom of clean oil compartment to avoid streams making contact with air

Fig. 6—Shows progress of oil from precipitation compartment, through filter units, to clean oil compartment

There is 144 sq.ft. of active filter cloth. In operation the oil is 2½ hours in passing through the filter. The cooling effect is, of course, considerable.

(To those who desire further literature on the subject of maintaining the quality of turbine oil in service, the writer suggests: Prime Movers Committee, N. E. L. A. Reports, both 1922 and 1923; "Testing the Quality of Lubricating Oils," paper by Winslow H. Herschel, in Proceedings, Engineers' Society of Western Pennsylvania, Vol. 38, No. 10, Pittsburgh, Pa.; Bulletin 11-A, Richardson-Phenix Division, S. F. Bowser & Co., Fort Wayne, Ind.; Technological Paper No. 223, Bureau of Standards.)

The following method of testing the tightness of the piston in the cylinder has been used with success:

1. Remove the cylinder head. Shore the piston to prevent upward motion.

2. Connect a steam hose to the lower drain cock and gradually raise the pressure to the working pressure. If the rings are not tight, steam will leak past them. It must be remembered that this test shows defects for only that part of the cylinder occupied by the piston. If measurements show that there is a great difference in size in various parts of the cylinder, the test should be repeated several times with the piston in a different part of the cylinder during each test.

Boiler Instrument and Control Boards

By W. R. Pender*

To insure efficient operation of the boiler and furnace, it is advisable to arrange the various controls and instruments in a central group which will permit the operator to make the various adjustments and observe the result of the operation on the instruments.

To meet these requirements the unit system with a centralized instrument and control board was developed as shown in Figs. 1 and 2. This system permits the control of all burners simultaneously by the use of a master valve with extension handles through the board controlling both fuel-oil and steam-atomizing master valves.

Each burner is equipped with a pressure gage on the oil and steam lines, as shown in Fig. 2. The gages are connected to the burner side of the regulating valves and indicate the pressure of the oil and atomizing steam that is passing through the burner. The valves at each burner are practically full open, with the exception of the minor adjustments required for each individual burner; then the master valves are regulated as required to meet the varying load conditions on the boiler.

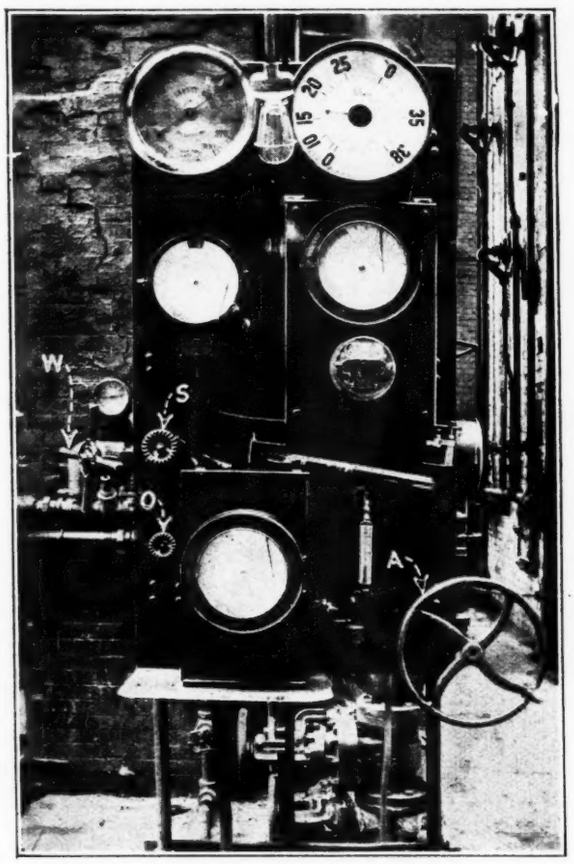

Fig. 1—Instruments and controls are grouped on one panel

The damper control wheel *A* with the extension shaft to the boiler damper, permits easy control of the air supply to the boiler furnace. The draft gages mounted on the board indicate the required draft for each load condition, the gage scale being constructed to allow all the necessary data to be plotted on the scale, as shown on page 362, Sept. 4 issue of *Power*.

The damper control can also be connected to control the master burner valves *S* and *O* through an adjustable cam which has previously been designed to conform to the required valve movement. With this arrangement the entire furnace can be controlled with one movement of the wheel *A*, thus eliminating the possible negligence of the operator in making the correct adjustments.

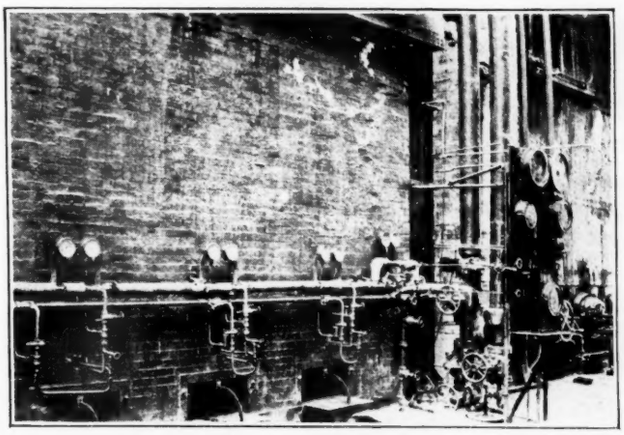

Fig. 2—Location of board and arrangement of connections to burners

The boiler feed-water control valve has an extension handle *W* at the left side of the board, and from this position the operator can adjust the water supply and observe the water gage glass. Having this control at the front of the board is an advantage, as the water supply requires adjustment when making any change in the fuel supply.

The large dial flow meter at the top of the board indicates the boiler output in horsepower. The graphic recorder and integrator are mounted below and record the amount of steam supplied by the boiler.

The recording flue-gas thermometer is mounted below the steam-pressure gage. This instrument affords a ready check on the boiler operation, as the temperature of the gas leaving the boiler is affected by several conditions of boiler operation and, when properly interpreted, will show the cause of low efficiency. The CO_2 recorder is mounted at the bottom of the board.

To generate steam efficiently, all the instruments shown on the board are essential. Given these and a progressive fireman, the results obtained with the fuel will never be in doubt.

With a given percentage of CO_2 in the flue gases, the boiler having tight settings, there is a definite relation between the readings of the gage under the boiler damper and the gage over the fire for each one per cent of rating of the boiler. This is known as the draft loss through the boiler. If the CO_2 becomes low, the difference between these readings for a given rating increases. If the CO_2 increases, the draft loss correspondingly decreases. This is due to the gas volume increasing with the admission of excess air, causing the velocity to become higher with added friction, and more inertia of the gas to overcome. Conversely, an increase of CO_2 reduces the friction loss and there is less weight of gas to be carried off.

*Combustion Engineer, Houston, Texas.

High-Power Mercury-Arc Rectifiers

The Rectifiers, Their Construction and Operation—Auxiliary Equipment—How the Rectifier Is Put Into and Taken Out of Service—Parallel Operation of Rectifiers and Rectifiers with Other Equipment—Regulation, Efficiency and Power Factor

BY F. C. BAILEY

OWING to its characteristics the high-power mercury arc rectifier provides an efficient method of conversion from alternating to direct current, and the latter form of supply is prevalent in England at the present time. In the construction of this equipment a semi-automatic form of control has been employed, thereby giving a close approximation to the ordinary transformer. By substituting complete automatic control, however, increased advantages could be obtained without undue complications to the existing control gear. On the other hand, it has been proved that the automatic arrangements are simpler than with the equivalent rotary converter.

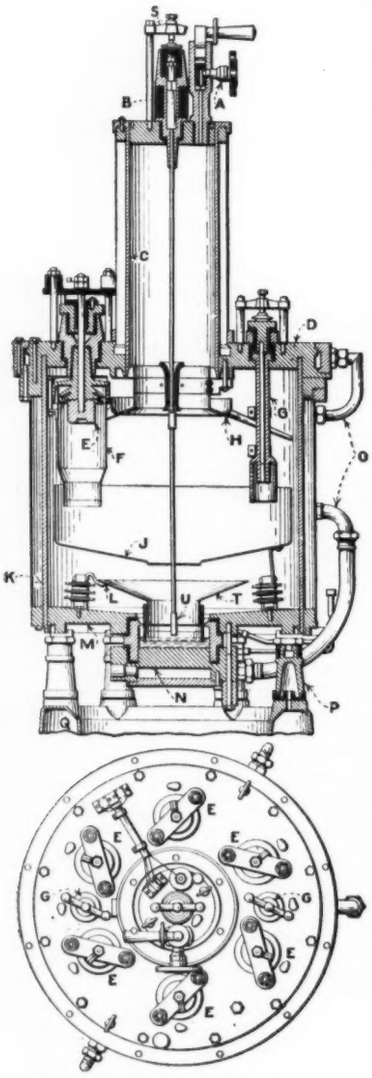

Fig. 1—Section through mercury arc rectifier

Electrification systems are now being taken up in various parts of England, and higher direct-current voltages are required. The rectifier is finding an extensive field, especially in view of the fact that these high direct-current pressures can be conveniently obtained, without encountering the serious difficulties sometimes experienced in other types of converter. In the following a description will be given of one type, known as the Brown Boveri.

The rectifier shown in detail, Fig. 1, consists of a large welded steel cylinder *K*, the arc chamber, and a smaller cylinder *C*, the condensing chamber, the two being connected by the heavy anode plate *D*. The bottom of the arc chamber is closed by plate *M*, in the center of which is the cathode from which the current flows. The top of the condensing cylinder is closed by the plate carrying the ignition coil *B*. The whole rectifier is mounted on porcelain insulators *P* which insulate it from the earth, these in their turn being carried on the foundation ring *Q*. As will be seen from the plan, there are six main anodes *E* and two auxiliary anodes *G* placed in a circle around the anode plate. The auxiliary anodes serve to maintain the arc when the load drops to a low value on account of the main arc having a tendency to become unstable under such conditions. They might be said to constitute a single-phase rectifier within a six-phase one, because they are connected externally with a small exciting transformer having a capacity of less than one kilovolt-ampere and provide an auxiliary arc, which keeps up the temperature of the cathode. The middle point of this transformer is brought out, as is done with the main transformer, and connected through a resistance and small reactance coil to the cathode.

CONSTRUCTION OF THE RECTIFIER

The main anodes *E* are made of soft chemically pure iron and screwed to the anode bolts, which serve to convey the current to them, the transformer connections being to the upper part of these bolts. The anodes and bolts are insulated from the anode plate by specially designed leading-through insulators, the portion nearest the anodes being provided with screening hoods formed integral with them. To the latter are fitted the sheet-iron arc guides *F*. These arc guides terminate in a large collecting funnel *J*, while immediately above the cathode there is a smaller funnel *T*, terminating in a thin cylindrical insulator, the purpose of which is to protect the main cathode insulator. The arc operates between the main anode *E* and the cathode, which path is well defined and eliminates to a large extent the possibility of backfiring. Just below the condensing cylinder *C* there is a mercury collector *H* into which the condenser mercury drops, and it is then led by the sloping troughs to the walls of the arc chamber *K* and finds its way back to the cathode.

Both cylinders are water cooled, the water first passing through the cathode base *N*, from whence it is led to the jacket round the arc chamber and the anode plate by the connections *O*, after which it passes to the jacket surrounding the condensing cylinder and then out to waste or to a separate recooling system. Down the center of the rectifier passes a rod connecting the ignition anode with the solenoid *B*. The cock *A* connects the rectifier with the vacuum pump. The anodes are rounded and are highly polished to remove all irregularities from their surface, which would be conducive to backfiring.

Three sizes have so far been standardized for dealing with 300, 600, and 900 amperes continuously, up to about 800 volts direct current. The largest size is shown in Fig. 2; the medium size is similar in appearance, but the smallest is not provided with the radiator

coolers for the anodes. These coolers are insulated from one another and the rest of the cooling system while they are filled with water, which is in actual contact with the top of the anodes and circulates on the thermo-siphon principle. For the higher direct-current pressures, now coming into more general use for traction purposes, three more sizes have been developed to deal with 250, 500 and 750 amperes and pressures up to 1,600 volts. They are provided with rather higher working chambers; otherwise externally their appearance is the same as that of the low-pressure ones.

A complete converter of this class consists essentially of the rectifier proper with its main transformer, vacuum-pump set, ignition converter, excitation equipment and the anode or equalizing reactance coil, where two or more rectifiers are running in parallel off one main transformer.

Starting Operations

As regards ignition compared with the operations required in the starting up of rotary converters, the rectifier is simpler and has other advantages. The ignition current is provided by an auxiliary 0.5-kw. converter set, though under certain conditions it has been found possible to ignite by alternating current.

Referring to the sectional diagram of the rectifier, Fig. 1, the ignition anode *U* is seen to be a short distance above the surface of the cathode, in practice about 8 mm., and connected to the solenoid at the top of the condensing chamber *C*. A push-button switch on the operating panel controls the ignition circuit, and pressed, a current of about 2.5 amperes passes from the small converter through the solenoid coil, thus causing its core to be pulled downward against the pressure of a spring, until the ignition anode touches the mercury. The connections are so arranged that when this occurs, the coil is short-circuited and the anode is pulled up again by the spring. An arc starts at the point of separation and immediately afterward the main arc is established and the set is switched on to the busbars. With rectifiers that are constantly in service, this is all performed in a second or two, no preliminary operation being necessary beyond the checking of the vacuum. Where a plant that may have been shut down for some time (24 hours or more), it is advisable not only to make sure of the vacuum, but to load the anodes separately for a few minutes through an auxiliary resistance supplied for the purpose, to heat them up and insure that each take the same load. As an example of the time in which rectifiers can be put on load, the case may be cited of the 800-kw. three-cylinder set recently installed at Berne, Switzerland, where the average time for all three rectifiers is five seconds.

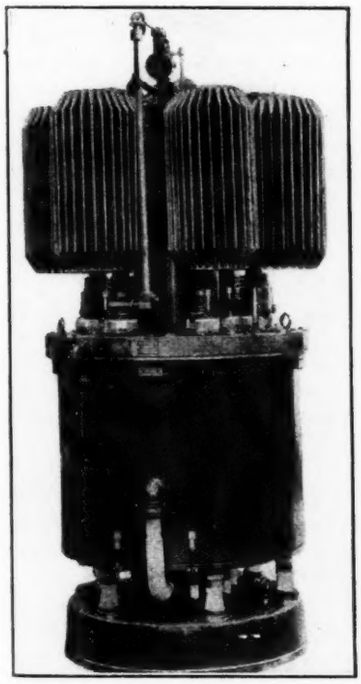

Fig. 2—Large mercury arc rectifier assembled

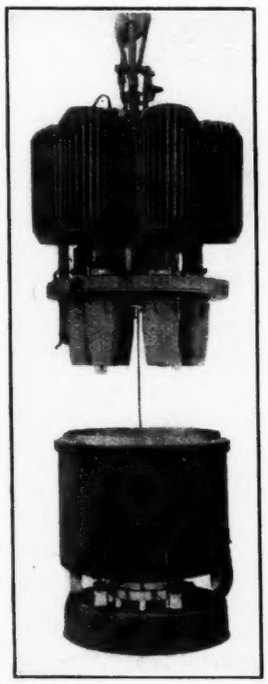

Fig. 3—Cathode raised from cylinder

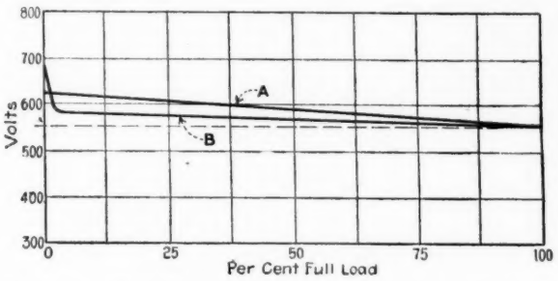

Fig. 4—Voltage regulation curves for mercury arc rectifier

Curve *A*, regulation without cathode coil; curve *B*, regulation with cathode coil in circuit.

Operating Two or More Units in Parallel

The operation of several rectifiers in parallel is easily accomplished by electrically interlinking the anode or equalizing reactance coils through an auxiliary winding on the latter, which insures that the current divides equally among the anodes in parallel. Where each rectifier is provided with a separate transformer, these anode coils can be dispensed with, the transformers being designed to give the desired regulation.

To enable rectifiers to work well in parallel with other types of converters, both must necessarily have approximately the same regulation characteristics, this requirement not only being peculiar to rectifiers but applying to all electrical equipments operating in parallel. To deal with higher loads than can be handled by single rectifiers, it is customary to connect two or three in parallel, all being fed by one main transformer. Such a combination would constitute one set and be equivalent to a rotary converter set of like capacity. Each rectifier should be provided with its own low-pressure panel, and though the switch-gear is to some extent duplicated there is the advantage that during periods of light load one or more of the rectifiers can be shut down. Another decided advantage is that the factor of safety is considerably increased because taking the case of a three-rectifier set for example, should one fail for any reason, it is still possible to deal with two-thirds of the load.

The rectifier proper has no regulating properties apart from its transformer and auxiliary gear, except for a slightly negative tendency of the arc with increasing load, which makes it necessary to insert the anode reactance coils already referred to. In the normal equipment where close regulation is not

required, there would be an inherent pressure drop up to about 12 per cent, but this can be materially improved by connecting a cathode reactance coil in the neutral of the transformer. To enable this coil to be used, the transformer secondary is arranged as two three-phase star-connected groups with the two neutral points brought out to the cathode coil. With these coils the regulation is usually from 5 to 6 per cent, from small loads of 10 to 15 amperes to full load, the two characteristics being similar to those shown in Fig. 3. It will be seen that curve *B*, which is that when the cathode coil is used, rises rapidly from a few amperes to no load, the difference amounting to about 15 per cent. As it is exceptional for plants to operate at such low loads, this rise of pressure is of little moment.

Methods of Voltage Regulation

A plant relying for voltage control on a cathode coil is one to be commended because it is simple and gives as close regulation as is needed for average conditions, but where it is desired to maintain the direct-current pressure constant at all loads or to increase the pressure with the load, other means of obtaining this must be adopted. As the voltage ratio between alternating and direct current is fixed, it is necessary to vary the former on either the primary or the secondary of the transformer. One method is by means of taps on the transformer winding and a step switch. Another way, and one to be preferred, is to use an induction regulator (hand or automatic controlled) either three-phase on the primary of the transformer or six-phase on the secondary, by which means any degree of regulation can be given according to the capacity of the regulator chosen.

The overload capacity of the rectifier, given equivalent conditions, is not inferior to that of any other class of converter; in fact, it has qualities in this

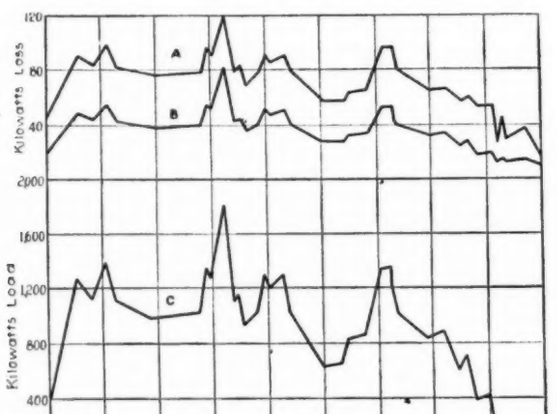

Fig. 5—Kilowatt load and loss curves

Curve *A*, kilowatts loss if load *C* is supplied by rotary converters. Curve *B*, kilowatts loss if load *C* is supplied by mercury arc rectifier.

respect that are superior. Normal load variations of whatever degree can be easily handled, while momentary overloads of 200 to 300 per cent can be taken care of without difficulty. The same can be said for short-circuits, the only indication that such have occurred being the indications of the instruments and the tripping of the circuit breakers. With the rectifier it is not possible to supply a three-wire system, consequently the usual course is to connect the rectifier across the two outside wires of the system and take care of the difference in load on the two sides in some other way.

Over-all commercial efficiency must include all losses in the auxiliary equipment such as the main transformer, excitation, vacuum pump and reactance coils. Owing to the comparatively small losses in the rectifier itself, it is possible to obtain over-all efficiencies that

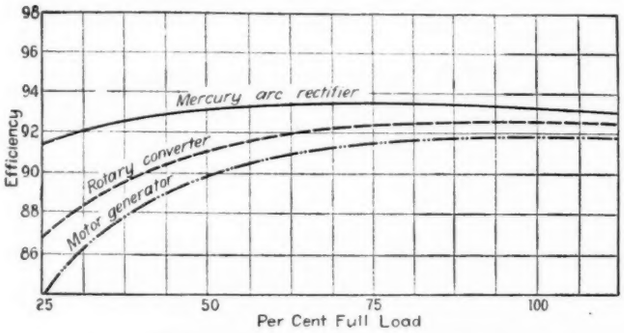

Fig. 6—Efficiency curves for different types of converting apparatus. Rating in each case is 1,000 kw., 500 volts, 50 cycles

are better than can be obtained with the rotary converter under similar conditions and assuming direct-current pressures above about 400 volts. It is possible in many instances where lower pressures are met for the rectifier to show a better efficiency than the rotary converter if the average load over the whole run is considered, especially where a plant may be running for long periods lightly loaded. As frequency has no bearing on the operation of this type of converter, it is of advantage to use the higher frequencies because of the lower initial cost of the auxiliary equipment and the benefit of the lower losses that result.

Efficiency and Power Factor

In the matter of efficiency the rectifier shows up to considerable advantage if a typical case is taken and the annual saving to be effected has been worked out on a basis of the daily load curve. By way of example the losses for the 1,200-kw. 1,500-volt sets have been plotted in Fig. 5, for an actual load, rectifiers and rotary converters both being of the same manufacture and designed for a 50-cycle system. The space included between the two upper curves represents the difference in the losses of the two types of converters, and if this is averaged out over the 18 working hours, it will be found that the rotary losses exceed those for the rectifier by about 650 kw.-hr. representing an annual loss of about 237,000 kw.-hr. An additional advantage with the rectifier is that its efficiency has a tendency to increase after the plant has been in use for some time, mainly due to the drop in the arc decreasing as the vacuum improves. In Fig. 6 are shown efficiency curves for a mercury arc rectifier, rotary converter and motor-generator set, all rated at 1,000 kw. 500 volts 50 cycles. The average power factor in rectifiers varies from about 95 per cent at full load to about 90 per cent at 25 per cent load. The power factor of the arc itself is unity but the figures given are for the whole installation including the transformers.

The Locomotive Crane as a Coal-Storage Machine

WHILE hand shoveling or portable conveyors have been found suitable where but a small amount of coal is stored, plants using 15,000 tons or more cannot afford to store a 60-day supply by such means. Since the movement of coal traffic is never uniform, it is the usual thing to find that a dozen cars are placed on the plant's siding at a time. To avoid demurrage charges, this coal, amounting to, say, 500 tons, must be emptied within forty-eight hours. A belt conveyor is obviously out of question and hand shoveling impossible from both a cost and a time viewpoint.

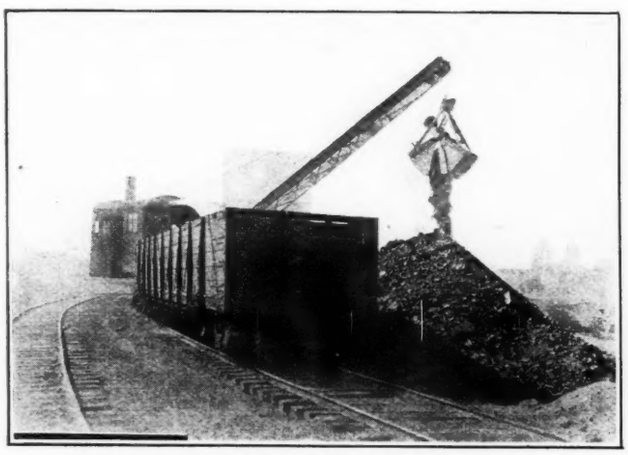

Fig. 1—Typical locomotive crane

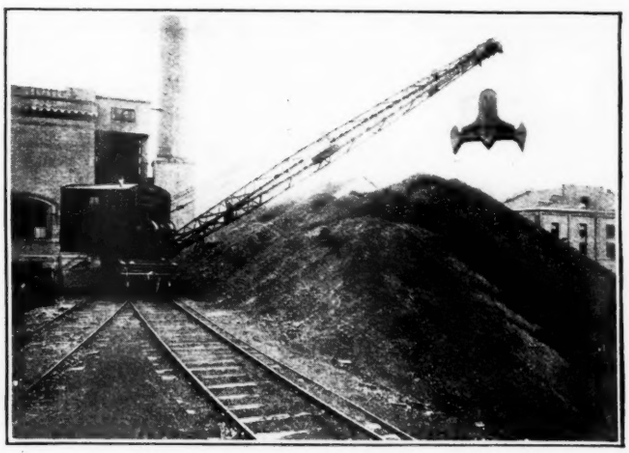

Fig. 2—Crane in an industrial plant

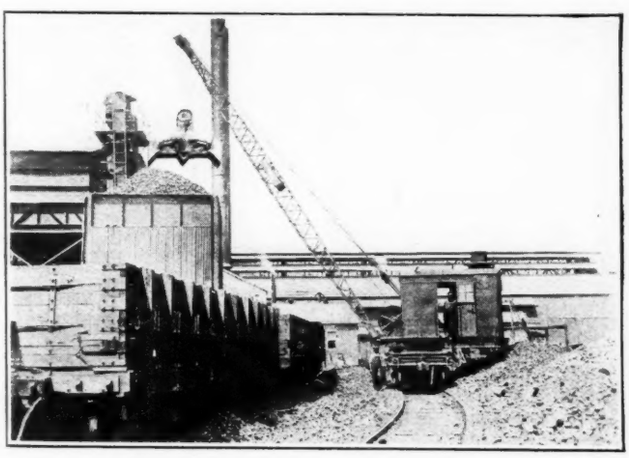

Fig. 3—Handling coal into both storage and bunker

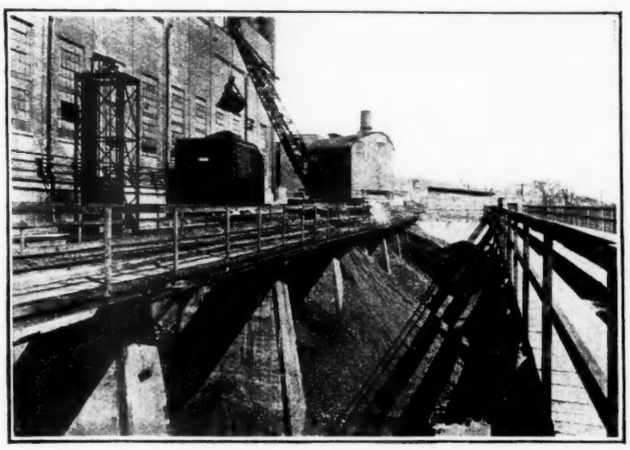

Fig. 4—Recovering coal by a crane

In the study of proper storing equipment one of the first machines to come to general attention was the so-called locomotive crane. This machine was a development of the railroad wrecking crane consisting of a jib boom and stiff-legged derrick mounted on a flat car. As now built for railroad use, the strongly designed truck carries a cab containing a boiler support for the boom and the hoisting mechanism consisting of a duplex engine driving the cable drums. A circular rack on the car meshes with a pinion which is driven by the engine through suitable clutches. It is possible to give the boom a considerable vertical movement and at the same time cause it to be swung in a complete arc by means of the rack.

It was quite natural that the railroad executives, when confronted with the problem of storing a large tonnage of coal, should turn to the wrecking-train track and make use of the crane, idle save when a wreck had occurred. By substituting a clamshell bucket in place of the wrecking hook, a machine was available that would unload coal from cars into the storage piles, both expeditiously and cheaply.

Railroads are larger users of coal and likewise store a greater tonnage than any other industry. That the locomotive crane was successful for them gave an impetus to its adoption by other industries, Fig. 2 showing a crane with an extra-long boom used by the Elgin National Watch Company.

Usually, the purchase of a locomotive crane to be used solely for coal storage is not justifiable, but since there are many other uses about a factory to which the crane may be put, frequently this machine will

store coal more cheaply than will any other system. The cranes cost from $10,000 upward, depending upon capacity, etc.

The life of the machine should be at least 20 years and when under steam will use between one-quarter and one-half ton of coal a day. Where license laws are in effect, a licensed engineer is necessary.

If the time spent in handling coal be charged against coal storing, the total average cost per ton will vary between 10 and 18 cents. This compares quite favorably with hand shoveling, which will average at least 25 cents a ton.

Where the storage pile is not immediately at the boiler house, means must be found for the reclaiming of the storage coal. In some plants an underground conveyor belt runs the entire length of the pile, the coal being dropped onto the belt through suitable gates, etc. This entails a considerable investment, not always justified by the amount of storage.

Reclaiming may be done by the crane if cars are available into which the coal may be dropped and the car then shifted to the boiler house. The crane is self-propelling and may be used in the car switching. However, the switching method of reclaiming is expensive and is to be avoided whenever possible, entailing the use of at least one man to do the switching besides the engineer.

If the coal storage can be placed near the boiler house, the crane can be used to unload from the car directly into the bunkers or into storage. The crane will reclaim the coal by swinging through 180 deg. after picking up a load, so that the coal is dumped into the bunker as shown in Fig. 3.

In Fig. 4 the crane is used for reclaiming only, lifting the fuel from the storage and dumping it into a hopper, which may be shifted along its track and which in turn dumps the coal onto a conveyor belt.

The crane shown in the foreground of Fig. 5 handles the coal from the cars into storage, while the crane on the roof of the boiler room lifts the coal and dumps it into the conveyor hopper shown close to the stack.

The locomotive crane is confined strictly to movement along the rails and its sphere of activity is correspondingly limited. To overcome this has been the effort of crane designers. A rugged although somewhat unwieldy machine is shown in Fig. 6. The frame is mounted upon broad-tired wheels and can be shifted, although at a slow rate.

The caterpillar-tread or track-laying system has been applied to cranes, as shown in Fig. 7. The crane is easily moved along the ground as desired, giving the widest possible range to its use.

The gasoline engine requires no banking fuel and in most locations no license is needed by the engineer. Lately, a large number of such gasoline-engine-driven cranes have been placed in service, one appearing in Fig. 8. This machine is driven by a 40-hp. four-cylinder gasoline engine.

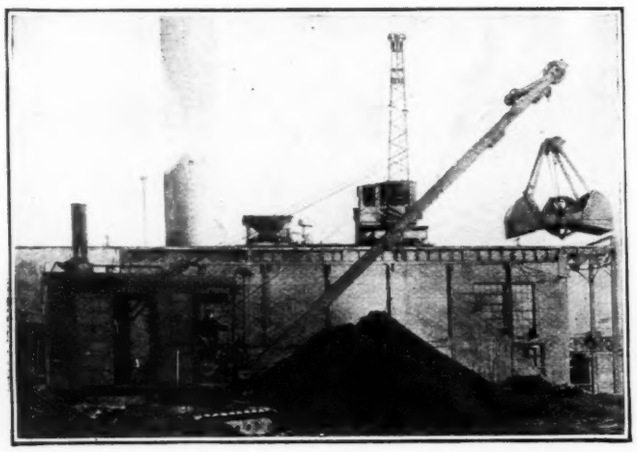

Fig. 5—Use of overhead crane in coal reclaiming

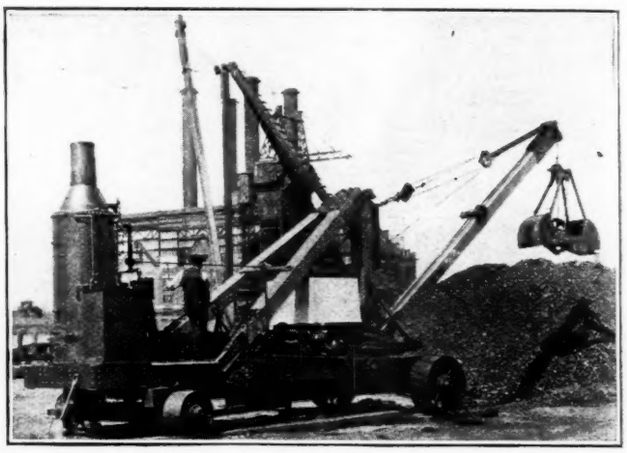

Fig. 6—Crane used in large central station

Fig. 7—Caterpillar-tread machine is popular

Fig. 8—Gas-engine handling crane

Checking Foundations for Large Turbines

Where reliability receives a maximum of thought, planning and careful execution, as in the case of a large prime mover, it is important that the foundation should always be capable of functioning to maintain proper alignment. The article discusses this and other requirements for foundations for Westinghouse turbines, as well as inspections before installing the unit, such as ordinarily devolve upon the service engineer in charge of erecting work. Acknowledgment is made to the instructions issued by the builder.

THERE is a general impression that where conditions and space permit, a concrete foundation is to be preferred to one of structural steel. It is regarded as more nearly monolithic in character and therefore less subject to vibration. This is true where unbalanced machinery (reciprocating engines) may be located more or less centrally on a block of concrete and where the desired end is secured by anchoring the machinery to a mass of many tons, the desideratum being tonnage rather than strength of structure.

Ordinarily, modern turbine foundations must provide generous openings for access to auxiliary machinery and partake more of a structure in which strength and rigidity rather than tonnage are the desiderata, which are more easily secured with structural steel. The modulus of elasticity of concrete under compression is one-tenth to one-fifteenth that of steel in tension, so that the natural vibration periods for reinforced concrete are lower than for steel members that occupy the same place.

Foundations for machinery are generally designed for rigidity, mass, etc., without regard to resonance. The various elements of a foundation for any type of turbine should be examined with this in view, remembering there will obtain a forced vibration corresponding to the r.p.m. of the turbine and certain multiples of it. The vibration of the elements of the foundation may be in a horizontal or vertical plane. One side or the other of a support may vibrate similarly or oppositely.

Usually, foundations of structural steel will be employed, although occasionally there is a predilection for reinforced concrete. While it is the purchaser's responsibility to furnish suitable foundations, the service engineer should look over the foundations and protect against any irregularity.

Whatever the form of foundation, a survey of the cover plates should first be made by stretching a wire along the foundation and determining that they are properly located and that they do not deviate more than one-quarter inch from the elevations shown on the outline drawing, so as to be assured there will be proper space for the screw chocks where required. This is important, for it may be discovered that, after certain of the turbine parts have been leveled, there is insufficient

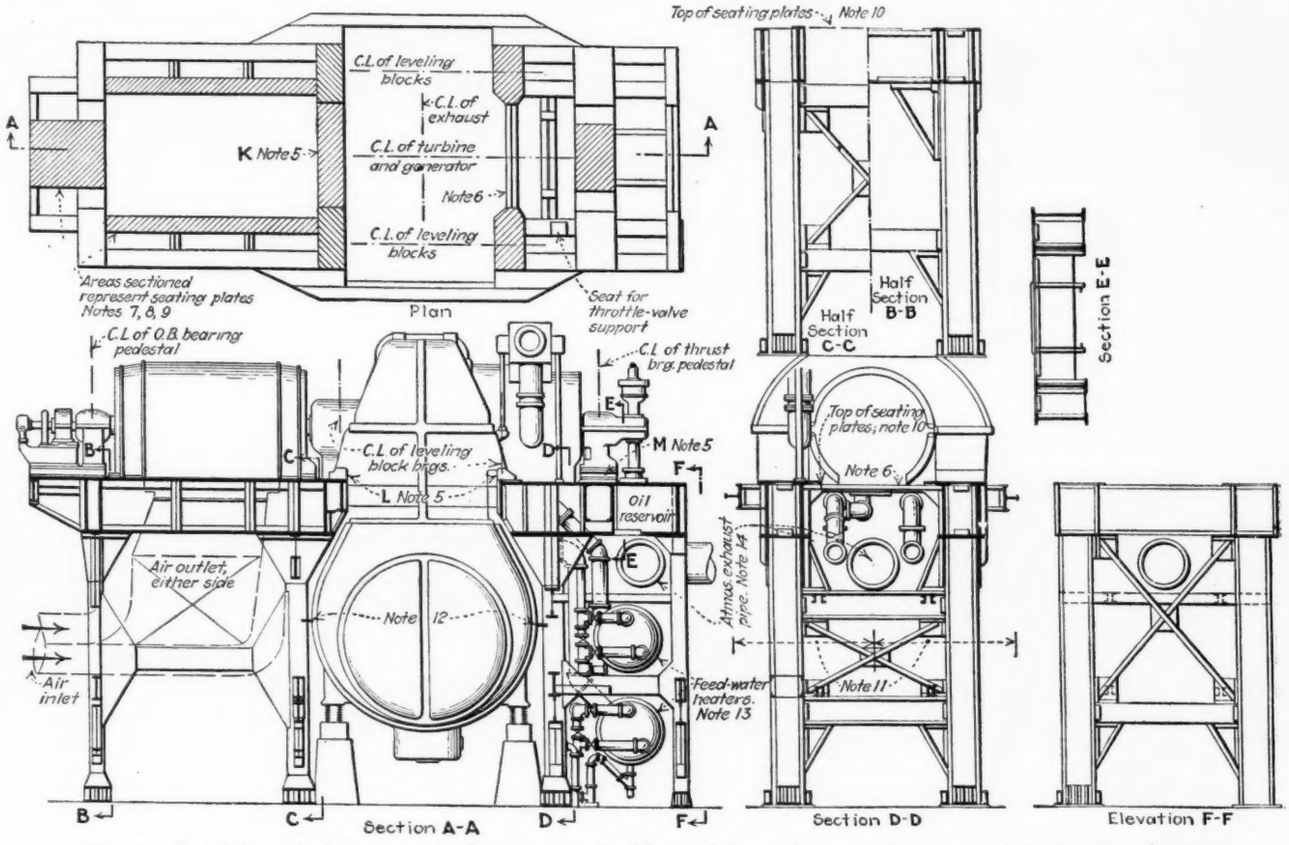

Fig. 1—Steel foundation suggested for large turbine with surface condenser and feed-water heaters

(See notes in Table I).

space for the insertion of screw chocks beneath others. This would ncessitate raising the parts that have already been aligned or incurring the expense of machining sole plates or pedestals to a shorter dimension. Methods of leveling are briefly illustrated in the description of a large Westinghouse unit in the May 15, 1923, issue.

A type of steel foundation suitable for these machines which is regarded as satisfactory, is suggested in Fig. 1. It is made up of steel girders and columns with steel seating cover plates not less than 1½ in. thick to which the turbine parts are bolted. The strength of the foundation should be such that the total deflection of any portion should not exceed 0.020 in. The riveting should as satisfactory is shown in Fig. 2. The concrete is first built up, then the cover plates are properly leveled and grouted. The drawing suggests a method of securing the cover plates to the concrete, particularly to prevent lateral movement. This is important, for the cover plates receive heavy lateral forces when moving the machinery on the foundations to align it, and further because of sliding of some of the turbine supports on their sole plates due to expansion and contraction.

The riveting of channels or I-beams to the cover plates which would reach down into the concrete should be avoided, for they may produce a line of cleavage in the concrete and be a source of weakness.

The pressure of the cover plates on the concrete

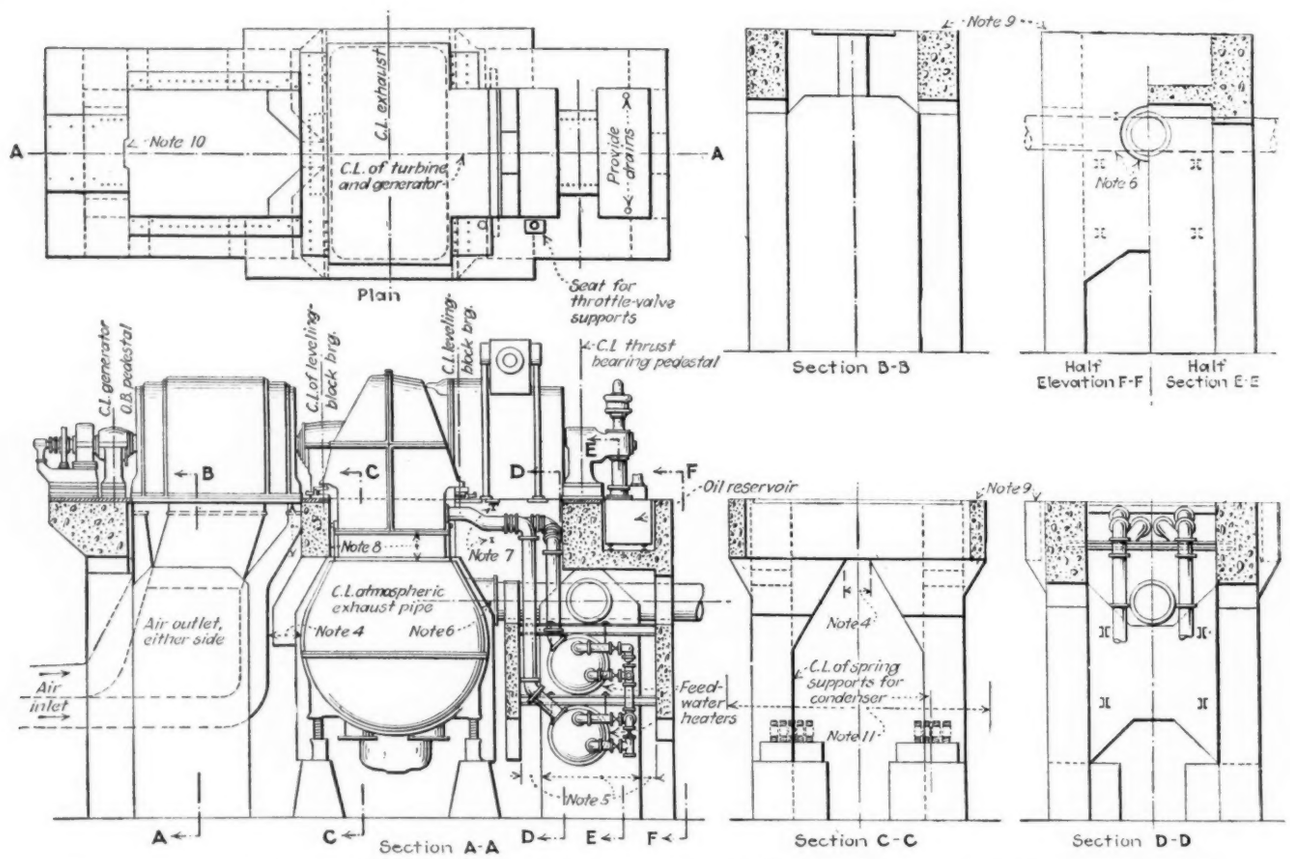

Fig. 2—Suggested reinforced-concrete foundation. The turbine cylinder is anchored at middle bearing, expanding toward the governor end

(See notes Table II).

be good, all rivets filling the holes, and the holes should be continuoues. Special observation should be made that the elements when riveted together, are in contact so that there cannot be local deflections of the flanges of angles, etc. The elements should be drawn together so that a feeler gage cannot be inserted between them. In particular, be sure that the cover plates bed thoroughly on their supporting steel so there will be no local deflections at these points, and that they are amply riveted so there can be no lateral movement. Sufficient bracing should be provided so that the turbine supports may slide on their sole plates by expansion and contraction due to heat, without causing lateral deflection of foundation. The generator portion should be tied to the turbine portion of the foundation in a manner such as indicated on the drawing.

A suggested reinforced-concrete foundation regarded should not exceed 250 lb. per sq.in. This may mean materially increasing the thickness of the cover plates from the minimum of 1½ in. which has been shown. A concrete mixture recommended to secure the maximum strength is 1 part portland cement, 2 parts sharp sand and 4 parts aggregate. The aggregate should consist of gravel, hard stone or other suitable material, which should be clean and angular. Anything passing a ¼-in. square mesh should be regarded as sand, the maximum allowable size of the aggregate usually approximately ¾-in. cubes and at least small enough to pass between all reinforcing bars:

The grouting should be 1 part portland cement and 2 parts sand.

In general, the strength of reinforced concrete may be improved from 25 to 100 per cent by attention to the following: The use of an excess of water in mixing is

most destructive. Exposure to sun or wind so that its moisture is lost rapidly, is undesirable.

The larger the aggregate the stronger the concrete. Washing of the aggregate if it is dirty will increase the strength 15 to 25 per cent. Thorough mixing is important.

A sheer allowance of 100 lb. per sq.in. of surface may be made for a smooth rod set in concrete and subjected to tension. The ultimate bond strength of smooth rods embedded in 1-2-4 concrete varies from 350 to 460 lb. per sq.in. of contact surface. A length of 50 diameters of embedment is a usual requirement for developing a bond resistance equal to the tensile strength of the bars.

TABLE I—NOTES REFERRING TO STEEL FOUNDATION, FIG. 1.

1. Fig. 1 is merely a suggested arrangement of foundation and is not to be used for construction. It is requested that purchasers submit their foundation drawings for examination and criticism.
2. Workmanship should be first-class in all particulars. Rivet holes must be accurately spaced so holes are continuous and rivets driven to fill. Built members must be true and free from twists, buckles, or open joints between component pieces. Abutting surfaces of compression members, unless fully spliced, must be finished to insure even contact. All surfaces inaccessible after assembling to be well painted or oiled before assembling.
3. For all dimensions and loading see official outline drawings, also steam inlet and drain piping drawings and arrangement of feed-water piping.
4. To insure ample rigidity the maximum total deflection of the foundation structure should not exceed 0.020 inch. To avoid undesirable resonance the natural frequency of any part of the unit, foundation, contiguous piping, or building structure should not be close to the speed of rotation or to the frequency of any generated current.
5. In addition to the vertical loads sustained the structure must be amply restrained against lateral movement during the erection processes and to resist forces due to friction. When certain of the turbine parts slide on their supports due to temperature changes such forces will occur at the four leveling blocks *L* and at the thrust-bearing soleplate *M*. For purposes of design these forces may be assumed to be 30 per cent of the vertical loading. The turbine proper is bolted to the seating at *K* only.
6. A combined strut and tie should be provided between side girders to resist lateral forces. For space available see steam inlet and drain piping drawings.
7. Thickness of seating plates recommended is 2 inches, minimum thickness 1½ inches.
8. Surface of seating plates must be true and level. Seating plates need not necessarily conform to outline of machinery feet requiring support but must be extensive enough to provide surface for the various chocks and transmit the load to the structure. Plates must not extend within the limit lines. For these lines, dimensions of feet, location of bolting and loading, see official outline drawings.
9. Drilling, tapping and spot-facing of seating-plates for adjustable chocks, leveling blocks and steam-chest support to be done at time of erection. Rivets joining seating plates to structure must be spaced to clear this drilling countersunk, and must be made flush on top. There should be sufficient rivets to pull girders and seating-plates into firm contact, but sectional area of seating-plates should not be considered in calculating girders.
10. If structure is encased in concrete, the concrete is to be considered as a protective covering only, the steel alone being made adequate for the loads imposed. Such a covering may have a cement finish carried up flush with top of seating-plates, which is usually the engine-room floor-level. If floor-level is above top of seating-plates, removable floor-plates should be provided for access to adjustable chocks.
11. Provide space as required for withdrawal of condenser and heater tubes.
12. Allow space for access to bolted condenser joints.
13. Provide for access to feed-water heaters and their piping.
14. Arrangement as shown permits of leading atmospheric exhaust pipe out at either side or at end.

TABLE II—NOTES REFERRING TO REINFORCED-CONCRETE FOUNDATION, FIG. 2

1. Fig. 2 is merely a suggested arrangement of foundation and is not to be used for construction. It is requested that purchasers submit their foundation drawings for examination and criticism.
2. For all dimensions and loading, see official outline drawings. See also suggested arrangement of seating plates, arrangement of feed-water heater piping, etc.
3. Concrete must be adequately reinforced for the loads sustained, with proper provision for lateral forces. To insure ample rigidity, the maximum total deflection of the foundation structure should not exceed 0.020 inch. To avoid undesirable resonance, the natural frequency of any part of the unit, foundation, contiguous piping, or building structure should not be close to the speed of rotation, or to the frequency of any generated current.
4. Allow space for access to bolted condenser joints.
5. Provide for access to feed-water heaters and their piping.
6. Arrangement as shown permits of leading atmospheric exhaust pipe out at either side or at end.
7. A combined strut and tie should be provided between side girders to resist lateral forces resulting from friction when turbine feet slide on their supports, due to temperature changes. For space available see steam inlet and drain piping drawings.
8. Exhaust connection is omitted when minimum headroom is required, and structural steel must be used where girders become too shallow for adequate strength in reinforced concrete.
9. Grouting is carried up flush with top of seating plates, which is usually the engine-room floor level. If floor level is above top of seating plates, removable floor plates must be provided for access to adjustable chocks.
10. In some cases a cut-out is required for collector leads. See generator lead drawing.
11. Provide space as required for withdrawal of condenser and heater tubes.

Prevention of Clinker Formation

BY D. C. HESS*

Clinker trouble is usually not so pronounced in most underfeed stoker installations until high ratings are reached and high furnace temperatures are being maintained. If the coal contains a low-fusing ash, it is evident that clinker trouble will be encountered. Clinkers in the fuel bed are hard to avoid, and in cases where they do not move to the rear with the travel of the fuel bed, a hook or slice bar is necessary.

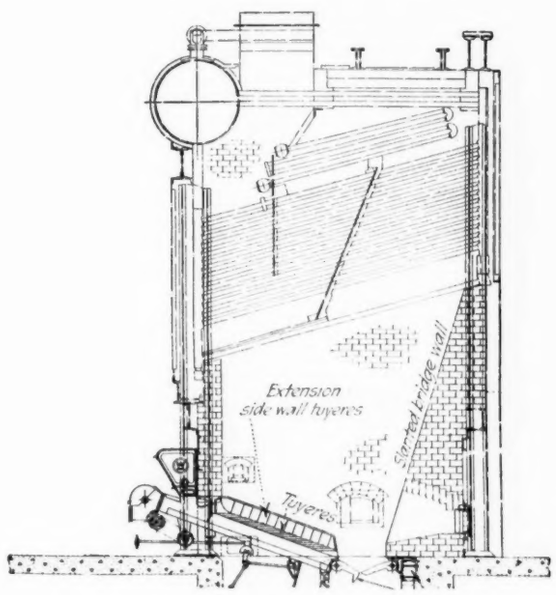

Fig. 1—Side elevation of boiler and stoker, showing sloping bridge wall

Recent changes in the design of boiler bridge walls tend to decrease furnace temperature and with it, to

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some extent the formation of clinkers. This is accomplished by sloping the front surface of the bridge wall backward so that the rays of heat impinging upon it reflect directly into the boiler tubes and not back into the fuel bed as in Fig. 1. Also, the latest engineering practice is to expose all tube surface possible to the fire, thereby decreasing the furnace temperature.

In some plants side-wall and bridge-wall clinker troubles are avoided by the use of steam jets. On the other hand, many plants are using side-wall tuyeres in

Fig. 2—Extension side-wall tuyeres used in furnace settings reduce clinker formation

connection with underfeed stokers as shown herewith. These side-wall tuyeres are cast-iron air boxes that extend above the side retorts and down along the side walls. They are rectangular in shape and fit closely together, but allow room for expansion and contraction. A large cored central space feeds air to the holes in the surface. The air issues at right angles to the wall or tuyere face.

At plants where these side-wall tuyeres are in use, the side-wall clinker trouble has been entirely eliminated, also the life of the boiler walls has been considerably increased. The maintenance of the tuyeres is very low, owing to air cooling the metal, and stokers equipped with these tuyeres burn high-ash Western coals and low-ash Eastern coals equally well. Several furnaces have been in operation over three years with satisfactory results. The air admitted through these side-wall tuyeres, Fig. 2, does not decrease the CO_2, as the air is admitted below the surface of the fuel bed and serves as an aid to complete combustion.

The value of the gas wasted by wells getting out of control when shot, far exceeds the value of oil similarly wasted. When a gas well goes wild, all the gas is lost, whereas much oil from a wild well can often be saved by erecting dikes. The principal loss of oil results from evaporation, seepage into the ground, and spray. Even an approximate estimate of the quantity of oil and gas wasted by wild wells cannot be made, but certainly it would amount to millions of barrels of oil and billions of cubic feet of gas.

As a matter of interest the world's record so far as known is 93.7 per cent efficiency secured on the 6,000-hp. wheels in the New River plants of the Appalachian Power Co. in Virginia. These turbines operate under hydraulic conditions that are comparable with New England rivers.

Steam Boilers

A Catechism by Warren Hilleary Served in Small Doses and Extending Over a Number of Issues

23. What is a dry-tube vertical boiler?

One in which the tubes extend above the water level during normal operating conditions.

24. Where should the fusible plug be located in each type of vertical boiler?

Submerged-tube type: In the center of the top tube sheet. Dry-end type: In any outside tube two inches lower than the bottom of the lowest gage-cock level.

25. What is the mud ring of a vertical or locomotive boiler?

A ring placed between the lower edges of the furnace and barrel sheets or between the furnace sheets and the wrapper sheets or throat sheets, and through which pass the rivets in the lower edges of the sheets. The purpose of the mud ring is to provide a surface that is easier to clean than the surface which would be present if the sheets were offset and riveted directly to each other. Also, the mud ring makes unnecessary the offsetting or bending of the lower edges of the sheets.

26. Where should the feed water enter a Scotch marine boiler?

Preferably on the side opposite to the one to which the water column is connected. The center of the opening should be level with the top of the upper row of tubes and eight to twelve inches back of the forward tube sheet.

27. A B. & W. boiler?

Through the forward head of each drum, on longitudinal-drum boilers, approximately six inches above the bottom of the heads.

28. A Stirling boiler?

Through the head of the rear top drum, approximately six inches above the bottom.

29. A vertical tubular boiler?

When the temperature of the feed water is higher than, say, 190 deg. F. there is no great objection in feeding through the blowoff pipe. But when the temperature is lower, as it is likely to be at times, feeding through the blowoff pipe would necessitate delivery against the hot furnace sheet. Hence, it is frequently inadvisable to feed through the blowoff.

While there are some objections to feeding at a point just below the normal low-water level, this appears to be the better way. It is inadvisable, however, that delivery be made directly on top of the lower tube sheet. The avoidance of such delivery is difficult unless the feed pipe extends downward immediately inside the shell, and so perhaps the least objectionable of all methods is to feed into a water-box or scale-separating device, provided there is free space enough inside the boiler for its installation.

30. Why are not fusible plugs generally used in water-tube boilers?

It is not possible to locate a fusible plug in any tube of a water-tube boiler and still leave the tube free for the travel of a tube cleaner, nor are the tubes of sufficient thickness to furnish stock for the thread necessary. The flat surface which in most boilers would accommodate the plug are generally not subjected to furnace gases of a sufficiently high temperature to fuse the alloy promptly.

31. What is pitting?

The wasting away of the internal surfaces of metallic vessels, generally through chemical action.

Other Lessons from Mount Hope

IN THE preceding issue of *Power* an editorial entitled, "How Process Plants Can Save Money," showed the absolute necessity of charging manufacturing departments with the actual steam and power consumed if any important savings are to be made in utilization. The argument found both its inspiration and practical demonstration in the remarkable story of the Mount Hope Finishing Company as told by H. M. Burke on page 109 of the same issue.

The article contained other lessons of equal importance, upon which space was lacking to comment at the time. One valuable idea, for example, was that of a "power dispatcher"—a man detailed as an intermediary between the power plant and the power- and heat-consuming departments. As the eagle eye over distribution and consumption such a man can save many times his salary in a plant of sufficient size. In smaller plants the same duties may profitably be taken over by the chief engineer.

Another valuable idea is that of a portable meter-testing outfit mounted on a truck. Still another is that of a meter board for the whole plant centralized in the dispatcher's office. Again, the "bogie" chart for boiler-room performance seems excellently adapted to boiler rooms anywhere. This chart shows by a line for each shift, day and week the equivalent evaporation per pound of fuel. Thus the men of each shift are put on their mettle to beat the previous records of their own and other shifts.

The methods that were thought out and the fact that they were actually put into successful practice reflect great credit on the management of the Mount Hope Company, and also upon the consulting engineer.

A study of the article raises one question of great importance, upon which good engineers equally well trained reach decidedly different conclusions. It is that of the proper charge for exhaust steam as compared with high-pressure steam. In the Mount Hope Finishing Co. the average price of high-pressure steam to the departments is around fifty cents a thousand pounds and of low-pressure steam thirty-five cents. These relative prices seem to meet one test of a good cost-keeping system, the test being that the system must be such that it will impel foremen and department heads to do the things that will save money for the company. In this plant, as is generally the case, the use of low-pressure steam in place of high-pressure steam saves money for the company. The lower charge for low-pressure steam leads the department heads to use it wherever possible. Therefore it automatically leads them to save money for the company. This reasoning seems hardly subject to dispute, yet one of the engineers discussing the paper questioned the propriety of these relative charges, saying that in his plant the same charge was made for both, on the principle that the charge should be in proportion to the value of the material, and that the low-pressure steam contains practically the same amount of heat and therefore has practically the same value. In a way this seems to be logical, and yet the first method of charging seems to stand the practical test better. The subject is one of such importance that *Power* will welcome letters discussing it in a constructive way.

A Difficulty in Proportioning the Amounts of Bled Steam

THE wider adoption of the bleeding of main units for heating feed water has brought to light a host of complicated calculations for determining not only the most economical and practical plant arrangement, but also exact amounts, temperatures and pressures of steam to be extracted.

A peculiar difficulty may arise. The heat balance of a plant is ordinarily calculated by the purchaser, which includes the amounts of extracted steam required. The thermal condition of the bled steam, however, must be figured by the turbine builder. These two calculations are to a large extent interdependent, and it appears to be to the interest of each party to await full information from the other before figuring results.

Determining the steam conditions of a turbine is ordinarily a matter of routine. Calculations, however, for conditions of steam bled at several points may prove a complicated problem and an extensive piece of work. Manufacturers may prefer that the exact amounts of extracted steam be specified, before furnishing information concerning thermal conditions.

In specifying the steam to be extracted, the engineer must know, among other things, the heat content at the desired pressures. He therefore may apply to the manufacturer for this information. The builder, however, requires the exact amount of extracted steam in order to make his calculations, so that the matter is apparently at a standstill.

There are several other courses possible. Among the data furnished with the turbine sales contract or proposal, may be a set of curves showing conditions at several bleeding points, including a table of various amounts to be bled, with resultant conditions. This, however, would ordinarily involve much labor, part of which would be useless.

Another method is for the purchaser to submit the approximate desired ranges of steam quantities extracted and then to obtain from the manufacturer, estimates of heat conditions such as may readily be made. Heat-balance conditions can be checked on this basis, and the amounts of extracted steam revised and again submitted to the manufacturer. Accurate turbine calculations can now be made, and the process of checking and revision repeated by both parties until sufficiently

accurate results are obtained. Here again there appears much wasted effort.

It would seem fairer in some ways and possibly more satisfactory, for the manufacturer to furnish basic data, such as a condition curve for the turbine and formulas suitable for figuring steam conditions with any desired amounts extracted. The plant designer then would be at liberty to make calculations just as extensive as desired, without inconveniencing the manufacturer. Turbine builders, however, are as a rule, loath to allow data closely aligned with design to be made public. It would seem, nevertheless, that some happy medium might be established whereby the purchaser could work out conditions from a fixed design, in a way suited to his interests.

Large units are frequently of special design, so that individual treatment is necessary. In the case of similar machines, however, bleeding calculations may perhaps be more conveniently handled by complete tabulations at the factory, which may be utilized directly or with slight corrections by a number of purchasers.

Both Are Insurance

PROPER protection of power equipment supplemented by inspection and maintenance schedules may be considered as insurance against failure of apparatus at an inopportune time, and the cost of doing this as a premium for such insurance. With good equipment properly installed the cost of such insurance is comparatively low considering the risk involved. The difference in cost for the best protection to power equipment and ordinary protection is so small that it can hardly be found in the carrying charges on the installation.

Differential relay protection on an alternating-current generator functions only in case of failure in the machine itself. It may be years after the machine goes into service before such protection will have occasion to act. In fact, these relays may never be caused to operate due to a failure of the generator. However, it is considered a good investment as an insurance against serious injury to the machine in case of failure in the windings. Large generators without such protection have practically destroyed both windings and core before they could be disconnected from the line and made dead when an insulation breakdown occurred. On the other hand, machines that have been properly protected have been known to fail two or three times in the windings with comparatively little damage to the machine.

Automatic engines stops represent a small investment compared with the damage that may result in their absence in case the main governor fails to function, and there is plenty of evidence to corroborate this statement. Not only have serious accidents occurred due to the absence of such stops, but they have also happened because the automatic stops were not maintained in proper operating condition.

What applies to large and important equipment also holds for small apparatus. A motor improperly protected against overloads may be entirely burned out, when a little consideration given to this feature would have saved the cost of rewinding the machine as well as the inconvenience of having it out of service and the consequent loss of production.

Inspection and maintenance of equipment is not only an insurance against failure, but also it has economic features that should recommend it to every plant operator. If a defect is detected and repaired before it develops into a failure, the cost of repair will generally be much less than would be the case after the failure. Maintaining equipment in a high state of repair, in many cases, results in a much higher efficiency than would otherwise be the case; particularly is this true of steam equipment.

It is becoming quite general practice to insure power equipment against failures, for which a yearly premium is paid to some insurance company. This insurance provides indemnity for the accidental breakdown of apparatus or in some cases the loss of production incident to equipment's failure. Such insurance serves an economic purpose, for the reasons that it requires a fairly high standard of maintenance of the insured apparatus and provides against serious losses should the equipment fail. Commendable as this may be, the plant still needs the insurance that can be obtained only by proper protection to equipment and efficient inspection and maintenance by the operating force. In one case a premium is paid to cover losses after they occur, and in the other a premium is paid in the form of carrying charges on additional investments and in maintenance charges, and the latter generally returns a handsome dividend on the investment.

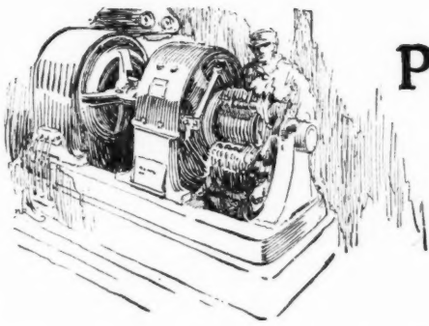
Shipping Board Befriends the Motorship

WHEN the Shipping Board was formed in the early days of the World War, one of its first acts was the ordering of a large number of Diesel engines for ship propulsion. Although these engines were rushed through the contractors' shops, the Board failed to provide the necessary hulls. Its dilatory tactics have been responsible for the neglect of the Diesel engine by the shipping companies, and the fact that there are a few American motorships in existence is due to the boldness of private shipyards and operators rather than to governmental encouragement.

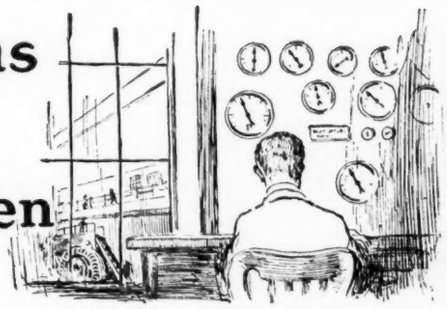
The Shipping Board has awakened to the seriousness of the competition offered by foreign motorships and has asked Congress for permission to put its new plan into effect. In general the plan is to make use of a portion of the funds resulting from the sale of the Board's vessels, to install Diesel engines in certain of those vessels which at present are powered by geared turbines. Since it will be necessary, in any event, to re-engine these boats either by steam or by oil units, the additional expense by reason of using oil engines will not be excessive.

In furtherance of its present policy of encouraging the motorship, the Board plans to sell vessels at five dollars per ton provided the purchaser agrees to install Diesels. By this arrangement the cost of the vessels, including the engines, will be well under seventy dollars per ton dead weight—in fact, under the cost of new steam cargo boats.

The question that remains unanswered is the effect on owners of steam vessels. It would seem that those who have gone ahead and built ships with their own funds will be sadly handicapped if the Board carries out its plan of lending to the various concerns the funds necessary to make the alteration in the Board's vessels. If the motorship is as profitable as claimed, and this is generally admitted, it should not be necessary both to make a present of the hulls and to lend the money.



Practical Ideas *from* Practical Men



How Troubles Multiply in the Power Plant

Josh Billings, or some other philosopher said, "You sometimes think you are all right when you aint." That trouble never comes singly was illustrated in our plant one hot Sunday night in August. The plant consisted of eleven water-tube boilers, four 400- and two 600-hp. Corliss tandem-compound condensing engines belted to generators and one 2,500-hp. Corliss cross-compound engine direct-connected to a railway generator. The "Big One," as it was called, had an independent condenser with a vertical reciprocating air pump controlled by a flyball governor. The other six engines exhausted into a common vacuum main that connected to a condenser at each end. All condensing water was obtained from a creek, and the hot water was returned there. At low tide it was sometimes difficult to maintain the vacuum, and when the vacuum was lost, the steam pressure was sure to drop very fast, but could usually be saved by a liberal use of fresh-water injection to the condensers.

On this particular Sunday we had put in a strenuous day, but in the evening the load had slacked off considerably and all the machines except the "Big One" and two of the small ones, which were to carry the load from midnight until morning, were shut down. Everything was running smoothly and the chief and the electrician had gone home.

About nine o'clock the head fireman came up and reported that he was about to clean two fires, as they were getting too thick. The tide was low at this time, and the pointer on the vacuum gage was hovering between 22 and 24 in., but the watch engineer said, "I guess we can hold her if you hurry up." In a few minutes the dynamo tender shouted, "Look out for the 'Big One!' At the same time, Snap! Snap! went two feeder circuit-breakers. The engineer ran to the engine and found it operating non-condensing, so he closed the valve to the condenser and hastened to turn on the fresh water, when he discovered that the air pump had stopped. In the meantime the vacuum had failed on the two small engines and the oiler was closing the valves. As the engineer raced back to try to get the air pump started, the engine-room lights went out. There were five series arc-lamps on one circuit. That left only the few lamps on the switchboard, and they gave no light anywhere else. The dynamo tender was too busy with the circuit breakers to put in a new fuse, the oiler had gone down to clean the strainers, and the steam-pressure was falling rapidly.

The chief was rather proud of his record of never having a shutdown during his administration and had repeatedly impressed that fact on his subordinates, so the watch engineer was somewhat worried. While the engineer was trying, in the dark, to discover the trouble with the air pump, the steam pressure had dropped so low that the "Big One" slowed down until the safety stop had disengaged the hook that held open the butterfly valve and stopped the engine. The oiler in the meantime had cleaned the strainers and with fresh water had brought the vacuum back on one of the small engines. The fires had been cleaned, and the steam-pressure was now rising rapidly. The circuit breakers had been manipulated so that the power had been on some part of the system constantly. One of the 600-hp. engines was started up and operated condensing with two of the smaller units.

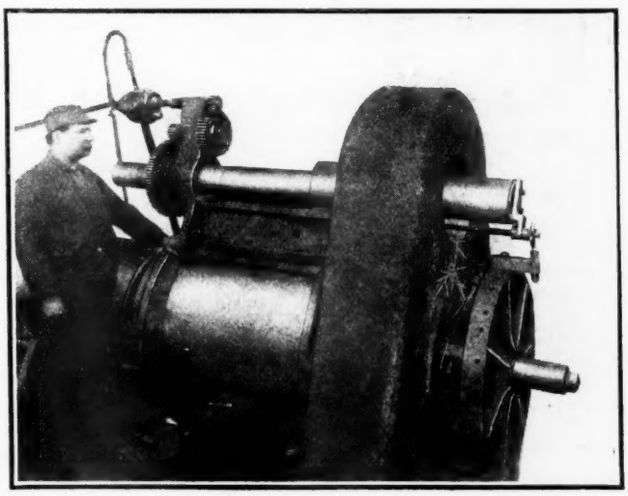
After the men had had time to get their breath, an examination of the air pump revealed the fact that the key in the gear on the vertical shaft of the governor had worked loose and dropped out. And it has been said that an engineer has only to "sit down and watch her run."

M. M. BROWN.

Utica, N. Y.

Reboring a Large Crankpin Hole

Recently, the crankpin of a large engine in our plant loosened, necessitating the reboring of the crankpin hole. As the time required to transport the shaft back and forth from the mill to the shop was too great, it was decided to rig up a machine to do the work at the mill and thereby save considerable time. The machine was of simple construction and is plainly shown in the illustration, so it is unnecessary to go into any detailed explanation. Perhaps the most interesting feature was the method of driving the cutter



Arrangement of boring bar and air drill for driving

bar. A common air drill was used for this purpose, the speed being lowered through the two sets of gears shown, the cutter bar sliding through the large gear as the bar was fed forward by the action of the star feed, seen at the extreme right. F. N. COAKLEY.

Buffalo, N. Y.

Stopping of Circulating Pump Causes Crack in Condenser Shell

An incident that took place at our plant a short time ago and the method of repairing the damage done, also the provision made to prevent a recurrence, may be of interest to readers.

The generating equipment consists of three units that are operated condensing, the circulating water being supplied by a motor-driven pump through a common line connected to each condenser. An additional pump is provided for emergency service.

One night recently during the light-load period, when only one unit was in service, the starter on the circulating pump opened, thus stopping the pump and cutting off the supply of water to the condenser. Before the trouble was discovered, sufficient steam had been drawn through the condenser by the air pump to heat the shell to a high temperature, with the result that when the water supply was again restored the water-box cracked between the flanges as shown in Fig. 1, the crack extending around the box from inlet to outlet as indicated by the lines *A* and *B*. The condenser was repaired the following day by painting over the crack with red lead and drawing it up with through bolts as shown.

As a means of preventing a recurrence of this trouble and to give an alarm the instant the circulating water

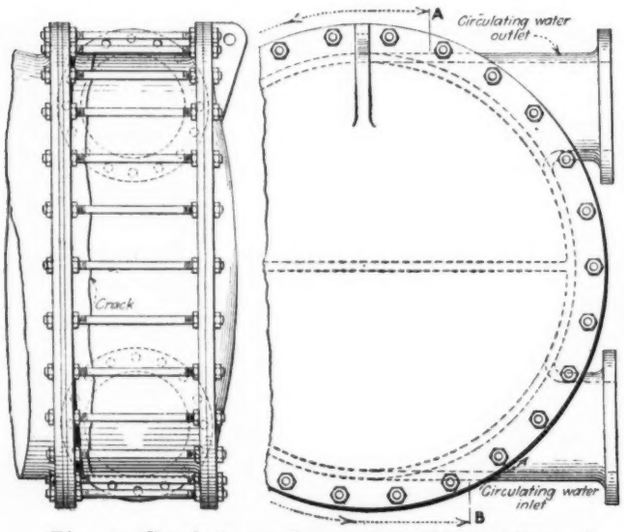


Fig. 1—Crack in condenser caused by failure of circulating water

head falls below normal, the device shown in Fig. 2 was developed.

It consists essentially of a U-tube made from ¼-in. iron pipe and mounted on a board as shown. One end of the U-tube is screwed into a globe valve from which the stem has been removed. This forms the connection for the water to the tube and also a convenient method of admitting the contact wire *B* into the tube.

In operation, the tube is about half filled with mercury, then the contact wire *B* is lowered until the bare end is well submerged in the mercury. It is then clamped in place by tightening up the gland nut *C*. The outer end of the contact wire *B* and the tube are connected in a bell circuit as shown.

When the circulating pressure is admitted to the tube, the mercury is forced down in the left-hand leg of the tube and up in the right, which action opens the bell circuit. In the event of the water supply failing for any

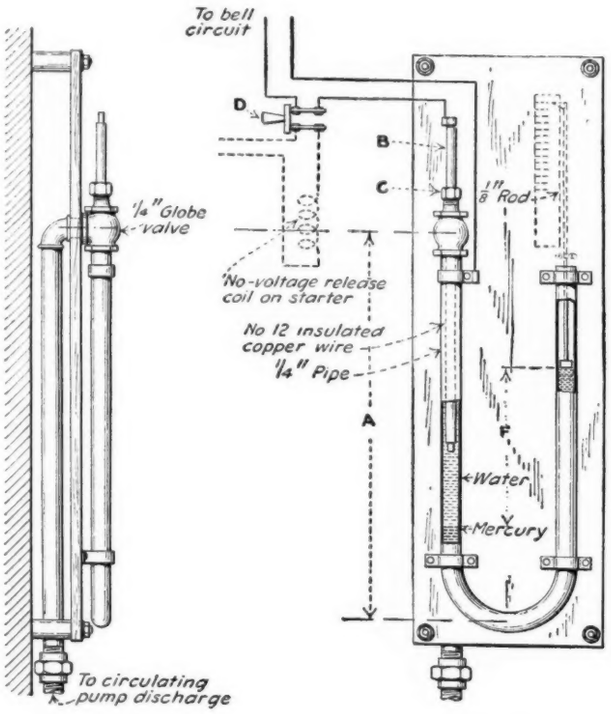


Fig. 2—Alarm used to give warning of failure of water supply

reason whatsoever, the mercury regains the normal level and completes the circuit between the wire *B* and the tube, causing the bell to ring and thus warn the engineer.

The two poles switch at *D* and the circuit shown by the dotted lines illustrate the method of coupling indirectly the alarm circuit with the no-voltage release coil on the motor starter. With this connection, when the pump is shut down the switch is opened to stop the bell ringing, but when the pump is again started, the switch must be closed to energize the coil and hold the starter in the closed position. This insures a closed bell circuit as long as the motor is operating.

For indicating the pressure on the lines at all times, an indicator can be made to float on the top of the mercury in the right leg of the U-tube as shown by the dotted lines.

The length of the U-tube or the distance *A* is calculated according to the pressure with which the tube is to be used. For example, if the maximum pressure on the pump discharge is 10 lb., the difference between the levels of the mercury, or the distance *F*, would be approximately 20 in. Hence the distance *A* should be around 30 inches.

If it is desired to have the alarm operate when only a slight drop in pressure has occurred the contact wire *B* is readily adjusted by loosening nut *C* and lowering the wire to the required position. H. N. THOMAS.

Newark, N. J.

Comments from Readers

Rumbling of Safety Valve

I read with interest in the Dec. 4, 1923, issue the reply to the inquiry of R. B. as to the causes of rumbling of a safety valve, and I agree with you that increasing the blowdown will in many cases overcome the chattering effect. I believe, however, that this is only a makeshift, as in most cases the rumbling is caused by improper installation.

From my observation I have found that practically all these causes come from having the valve placed too far away from the boiler. The A.S.M.E. Code recommends that the valve be connected directly to the boiler, and I have found some cases where they have used a piece of intervening pipe 4 or 6 ft. long. In other cases the valve is placed on top of a tee, the side outlet of the tee supplying steam. When I have mentioned this to engineers they have somewhat hooted my suggestion, but in many cases where a valve has been replaced and fastened directly to the boiler, the same valve, without any resetting, has given excellent service, and I suggest to all those troubled with this condition that they look at the installation before attempting any other elements. LANE THOMPSON.

Pittsburgh, Pa.

Common-Sense Examination Questions

I was much interested in the list of examination questions on page 1025, Dec. 25, 1923, issue. The state that uses such a list is to be congratulated. I have looked over several lists of questions that had been used for first-class examinations, and in my opinion the list referred to is away ahead of any other I have yet seen, so far as practical common sense is concerned. The questions are such as a man in charge should thoroughly understand and be able to answer.

When the Ontario Association of Stationary Engineers was issuing certificates, I was examined and succeeded in securing first-class papers. I had recently completed a correspondence course in steam engineering, and before going up for examination I put in a couple of weeks skimming through the entire course to refresh my memory; otherwise I should have failed to pass. At least seventy-five per cent of the questions asked were purely technical and of such a nature that an engineer in charge would never have to answer or solve them without first consulting books of reference. I am convinced that a month or two after I had passed the examination I could not have done so again without first going over the course as formerly.

No man of ability will depend upon his memory to solve involved and important engineering problems. In all cases he will refer to data. This being the case, why is it that lists such as the one in question are not more frequently used? The more I study it the better it looks, and a man need not be a college or science graduate to become a successful contestant.

I notice there are no questions on electrical or refrigeration practice, but these could be added and doubtless were in the examination. The examiners who use such lists deserve the thanks of all good engineers. If they were more frequently used, many a capable man would be holding first-class papers who has failed to answer successfully some of the fool lists now in use.

Toronto, Canada. JAMES E. NOBLE.

Straight-Edge for Reading Nomograms

Referring to the article in the Nov. 20, 1923, issue, "Making a Straight-Edge for Reading Nomograms," readers of *Power* will probably be interested in a method that I consider quicker and better than the use of a straight-edge or hair-line.

Take a fine sewing needle and run the point into a lead pencil or stick of about the same size as a pencil so that the needle will be held with the eye pointing outward from the end of the pencil or stick. Tie a knot in one end of a fine thread—the finer the better. Then thread the needle and pull the thread through until the knot is pulled up against the needle.

In nomograms we always have two known points. When using this alignment chart, place the end of the needle on the known point farthest to the left and pull the thread taut. Then move the thread upward or downward until it intersects the second known point. You can then instantly read the third, or unknown, intersection.

It is obvious that this method is better than using a straight-edge because the straight-edge must be placed to coincide with two points at once, which is not an easy thing to do. With the needle we first locate one point and then the other in logical sequence, and there is no hunting around as with a straight-edge.

One tryout of this method, I feel sure will prove its merits. L. W. LOWERRE.

Elizabeth, N. J.

[In using the straight-edge described in the Nov. 20, 1923, issue, a *single* point is first located with a needle and the edge pivoted around the needle at this point until it passes through the second point. If a needle is used with a straight-edge, it is unnecessary to locate more than one point at a time.—Editor.]

Retubing Boilers with Bulged Heads

The article by R. A. Cultra in the Dec. 18, 1923, issue and that of J. A. Benefiel in the Jan. 8 issue on "Retubing Boilers with Bulged Heads," call to mind an occurrence at the shops of the Northern Central Railroad at Baltimore, Md.

At the time referred to, it was the general practice to remove the flues for cleaning by cutting them loose in the firebox and pulling them through the front end. They were then cleaned by "rattling" and each had a new section welded on at one end, the remaining old end being trimmed to insure satisfactory connections with the flue sheet.

When the flues were removed, it was customary to measure the length of each by running a long stick through the holes in the flue sheets and marking on this stick the different lengths required. As Mr. Benefiel says in his article, there was always a variation in the length of the tubes, but it seldom amounted to much, and possibly only four or five different lengths of tubing would be necessary. The boilermaker doing the measuring would indicate the position of the different lengths by painting a white line around the tubes of each group having the same length and giving this group a definite number. The flues were then cut to correct length, allowance being made for beading, before they were delivered to the boiler for replacement. On the occasion under discussion these operations were completed according to general practice, but none of the flues except the first row next to the outside shell were of the proper length. At first it was thought that an error had been made either in marking the measuring stick or in cutting the flues to length, but an investigation showed that apparently the measuring stick was properly marked and the flues properly cut.

In order to determine exactly where the responsibility for the error lay, a further investigation was carried out, and it was found that the front flue sheet had sprung approximately one-half inch from its true position, though no reason could be found for such a change. It was reasonable to suppose that when installed the flue sheet was the correct size and shape, and this supposition was borne out by the fact that the flues that had been removed were of approximately standard length. The strain that these flues were probably under must have been tremendous, and the fact that they remained tight spoke well for the workmanship of the boilermakers who had installed them.

The flues were re-ended and cut after the necessary measurements had been taken, and were rolled and beaded into place. Whatever the cause, the change in the front flue sheet was permanent as shown by the fact that in subsequent trips to the shop for general overhauling the length of the flues remained the same.

Scranton, Pa. R. BAGLY.

Formula Applicable to Perfect Gases

At the bottom of page 810 of the Nov. 20, 1923, issue the following formula appeared: $P \times V = \frac{10.7 \times W \times T}{m.w.}$, where P = absolute pressure, in pounds per *square inch*, W = weight of the gas in pounds, T = absolute temperature, deg. F. (not ordinary temperature reading), $m.w.$ = molecular weight of the gas.

This formula is another, and rather unusual, form of the simple formula $PV = WRT$, which is known in engineering thermodynamics as the characteristic equation for perfect gases.

In this latter formula, however, it is important to note that P is the absolute pressure in pounds per *square foot* and R is what is known as the gas constant, depending for its value upon what particular gas is to be considered. W and T mean the same as in the first formula.

While PV looks the same in each formula, it is evident that the numerical value would be different, since the pressure in pounds per square foot equals 144 times the pressure in pounds per square inch.

As the practical men about the various plants are accustomed to having pressures stated in pounds per square inch, it might seem desirable for them to have a formula in such form that substitution for pressure could be made directly in pounds per square inch.

However, PV in the second formula represents work done in foot-pounds, in which case it is necessary to have the pressure stated in pounds per *square foot*. For the other side of the equation $\frac{10.7}{m.w.}$ equals $\frac{R}{144}$ while W and T are the same in each formula.

The value of what is known as the "universal gas constant" is given as 1,544 by the man who is supposed to have originated the term. Then $\frac{1,544}{144} = 10.722$, but 10.7 is close enough for ordinary calculations.

I submit this to call attention to the importance of substituting proper units in formulas and to give a brief idea as to how the formula is devised.

State College, Pa. O. K. HARLAN.

Shortness of Water and Overheating in Steam Boilers

In a recent issue of *Power* there was a report of a boiler explosion attended with loss of life. The coroner's jury gave a verdict stating that the accident was caused by the introduction of cold water into an overheated boiler. This must be considered an unsatisfactory verdict from an engineering standpoint, however much it might appeal to a body of laymen called upon to express an opinion on a matter that must be beyond their ken.

This question of the effect of putting cold water into a boiler that is overheated is one that often arises, and it is worth a little study. Obviously, the type of boiler has a great deal to do with the effect of overheating in the first place. There are quite a number of explosions occasioned by shortness of water. In the same issue of *Power* that contains the report under discussion, there was an account of a locomotive boiler explosion that was undoubtedly caused by shortness of water.

In considering the effects of overheating, the three general types of boilers should be considered separately. These are, the horizontal return-tubular, the internally fired, and the water-tube.

Taking the internally fired types first, we have the Scotch marine, of which there are a number in use for stationary purposes in both the United States and Canada, the vertical-firebox boiler, with dry or submerged tubes, and the locomotive type.

In the Scotch marine boiler the first part to become exposed is the top of the combustion chamber. In this kind of boiler the combustion chamber top is considerably higher than any other part exposed to heat excepting the tubes themselves, and it is a few inches higher than the top row. The water level is so arranged that the bottom of the gage glass is about four inches above the combustion chamber top. Now in marine practice, if the water level carried is low, it is not unusual, with a ship rolling, for the tops of the wing combustion chambers to be continually uncovered and covered again by the water. This is only momentary, but it goes on for days at a time in thousands of cases without any apparent harm being done. Leaving this out of the question and coming to the case of a real overheating occurring through the combustion chamber

top being uncovered long enough to get really hot, what happens? In the majority of cases the top or crown "comes down." That is, it buckles, sometimes without fracturing, but causing sufficient distortion of the side plates to bring about leakage of the tubes or leakage at the seams where the sides and top join.

In the Scotch type of boiler shortness of water must necessarily attack the combustion chamber crown before any other part. Therefore there is but little probability that the water level will ever become low enough to uncover the furnace. There are many cases of collapsed furnaces, which are usually due to scale or oil getting on the crowns. The amount of collapse varies, but rarely is it sufficient to cause actual rupture of the plate. The corrugated furnace is, of course, immensely strong as against collapsing pressure, and the overheating is usually of a local character, so that the distortion is confined to a small area compared to the whole.

Partial collapse of furnace crowns is not unusual in marine practice, and many ships have made long voyages after such an occurrence. It will thus be seen that shortness of water in this type of boiler, while detrimental and leading to accident, does not usually result in disaster.

In the locomotive type of boiler the highest heating surface is the furnace crown, which may be of the flat construction, the rounded or wagon top, or in small units, the dished or corrugated, which requires no staying. Exposure of this crown to the furnace heat on the fire side, and the steam in contact with the opposite side, leads inevitably to serious damage and frequently to disaster.

In the vertical-tubular boiler there is such a considerable distance between the furnace crown and the normal water level that shortness of water will make itself apparent in an external manner before much damage can be done internally. In this case, as the water level lowers, the first effect will be superheating of the steam and a more rapid generation of pressure. Owing to the high temperature some of the joints are likely to leak and the safety valves blow off, and thus attract the fireman's attention before serious damage results.

In the water-tube boiler there is less evil attending on shortage of water than in either of the types already mentioned. In the first place the temperature of the gases reaching the drum is comparatively low. The level can drop considerably below normal working height before much damage can ensue. In one case that came to my attention the result of low water was leakage of the rivets securing the angle irons to the outside of the drum, these angle irons being used to support the brickwork between the drums. If the water gets out of the drum entirely, splitting of the upper tubes is likely to result before anything serious happens to the drum itself, and although this is serious enough, it is not likely to result in extensive damage. The fact is that an explosion of a water-tube boiler, other than failure of tubes, is unusual, and those that have occurred have not been traced to shortage of water, but rather to failure through other causes.

The horizontal return-tubular boiler, being by far the most common type in use, is more familiar to the average engineer than the others. Lowering of the water level in this kind of boiler, below the bottom of the gage glass, will expose first of all the top row of tubes. If the boiler is set in the usual way, the front end, which is the coolest, is exposed before the back end, and the difference of temperature between the gases at the front end of the tube and the steam surrounding it, will not be more than 350 or 400 deg. The result, then, in the ordinary course of events, would be that the front end of the tube would not get much hotter than a temperature nearly equal to that of the flue gases, or about equivalent to a blue heat. The tube plate, however, is much thicker than the tube and will be exposed on one side to the heat of the steam and on the other to the heat of the flue gas at the top, while lower down it will be exposed to water at the same temperature on the inside and to somewhat hotter flue gases on the other side. The temperature of the tube sheet will thus be greater at the top than lower down and will be distorted locally, usually resulting in leaky tubes. In some cases of severe overheating, buckling of the plate occurs, this being due to the tube plate in the steam space being stiffly stayed, while the holding power of the tubes is decreased by the expansion of the tube holes.

It is obvious from this that long before shortness of water could have reached the stage where the shell plate over the furnace would be dangerously overheated, there would be enough leakage from tubes to call attention to the impending danger. In my opinion there is not much chance of such an occurrence. Where furnace plates get overheated, it is due to the presence of deposits that insulate the heating surface and not to the actual absence of water from the boiler.

Coming to the question of putting cold feed water into a boiler that is short of water, in no boiler that is properly installed is the feed pipe arranged to deliver directly on a heating surface. The feed water, before it could strike directly on an overheated plate, would be considerably raised in temperature by passing through the portion of the pipe that is inside the boiler, and after leaving the opening, if it had no water to resist its passage, would be sprayed out and not be in the form of a solid jet. If it could continue in the form of a solid jet until it struck the hot plate, it would, of course, although heated, be considerably below the temperature of the heating surface it would strike. Even so, the area of the feed pipe is so small compared with the volume of the boiler, that it would immediately be converted into steam on striking the heated surface. While it might set up a severe local stress at the comparatively small area with which it came in contact, it is extremely doubtful that this would be sufficient to cause any extensive rupture of the plate.

The writer is of the opinion that the feeding of cold water into a boiler that is short of water is a very inadequate explanation of an explosion, and feels that in inquiries of the kind mentioned at the beginning of this article, investigation should be pursued further and the real cause determined. It is not to be inferred from this that the indiscriminate turning on of the feed should be resorted to in all cases of water shortness. The old rule is the safe one. If the water has been seen positively within a few minutes of the discovery of the shortage, it is quite safe to put on all the available supply. If doubt exists as to when the water was last seen, then the fires should be smothered, pressure worked off and a proper examination made as to the cause of the shortage and the actual level of the water. Quick and decisive action, dictated by good judgment, is the first requisite in all these cases.

Toronto, Ont., Canada. T. H. FENNER.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Water Hammer in Pipe Lines

What causes water hammer in pipes and what can be done to prevent it? *R. L. G.*

When the valve in a water pipe is closed while the water is flowing, the water behind the valve is retarded and a dynamic pressure is produced. When the valve is closed quickly, the "water ram" or "water hammer" may be great enough to break the pipe or fittings. Because of friction and elasticity of the pipe material there is some dying away of the intensity of the pressure in the upper sections of the pipe, but the notion that the effect is concentrated at the downstream end of the arrested column of water is incorrect. The danger to rupture can be prevented by cushioning the line with air chambers or by relief valves and also by arrangements that prevent the stop valves from closing quickly.

Water hammer in steam pipes results from the impact of globules of water or wet steam that have been projected at high velocity through a portion of steam space in which the condensation has reduced the pressure. It is revealed by a sharp cracking or snapping noise in almost any pipe where there is rapid condensation of steam and where provision is not made for drainage, larger quantities of water thus gathering in a pipe system may be picked up and projected at intervals with enough velocity to rupture pipes or fittings. The remedy is to warm up the steam pipe lines gradually, protect the sections not required as heating surfaces with non-conducting coverings, and provide all pipes with a good pitch downward in the direction of steam flow, with suitable reliefs for the water at elbows, valves and low points in the pipe lines.

Re-evaporation Indicative of Loss

What is re-evaporation in an engine cylinder, and why is raising of the expansion curve from re-evaporation indicative of loss from cylinder condensation? *R. W. S.*

During the period of admission part of the steam is condensed from coming in contact with the metal of the cylinder which has previously become chilled by the lower temperature of the exhaust. This initial condensation raises the temperature of the cylinder walls. As the stroke proceeds, the reduction in pressure due to expansion lowers the temperature of the steam, with the result that abstraction of heat from the cylinder takes place, causing a partial re-evaporation of the water and raising of the expansion curve.

Work thus realized from re-evaporation at lower pressure is less than if the expansion took place from steam at the initial temperature and pressure containing the same quantity of heat; and re-evaporation of the condensate is never complete, as there always is a quantity of unevaporated water at release; and owing to the low pressure during exhaust, the unevaporated water is partly re-evaporated, increasing the back pressure. Hence re-evaporation, revealed by a higher expansion curve, is indicative of cylinder cooling that causes less efficient expansion and higher back pressure of the exhaust. However, it must not be concluded that because an expansion curve is higher than the theoretical curve, the difference is to be attributed solely to re-evaporation of condensate formed by cylinder cooling for, under ordinary conditions, the rise from re-evaporation alone would be only feebly shown in an indicator diagram. When the rise of the expansion line is very pronounced, it is mainly due to valve leakage.

Correction of Steam Consumption for Moisture

If the measured steam consumption of an engine is 27½ lb. per hp.-hr and the steam supplied contains 3 per cent moisture, what should be considered to be the steam consumption if the engine were supplied with dry saturated steam? *W. E. T.*

In determining engine economy the presence of a small percentage of moisture is regarded as neither increasing nor decreasing the amount of dry steam required. The quantity of dry steam consumed is determined by deducting the percentage of moisture found by calorimeter test of steam supplied at the throttle, from the total amount of boiler-feed water (with proper corrections for leakages and other losses), or from the gross amount of steam used, determined by condensing and determining the weight of the exhaust. Hence, where the steam supplied at the throttle contains 3 per cent moisture and the gross quantity of wet steam supplied is 27½ lb. per hp.-hr., the dry steam consumption should be considered to be $27.5\ (1 - 0.03) = 26.68$ lb. of dry steam per horsepower-hour.

Distribution of Power Costs Among Departments

What scheme would be practical for recording the horsepower used by various units of a mill to work out a proper distribution of our costs in different departments? As the loads constantly vary, single tests would not be satisfactory. *J. W. E.*

The power transmitted to different departments through electric motors could be determined from electrical recording instruments. But if the transmission is by shafting, the division of the whole load could be determined by placing a transmitting dynamometer at each principal point of distribution For most practical purposes employment of continuous recording instruments would be too complex and expensive. Distribu-

tion of costs could be made with accuracy, sufficient for all practical purposes, from the use of a single dynamometer to determine of one department after another (1) the shafting power changeable and (2) the number of horsepower hours chargeable to each department in its performance of work turned out or per unit turned out by the concern.

A schedule may thus be constructed for each department which would be checked or corrected by tests whenever desired. The data of tests of power in each department should be obtained with reference to kind of raw material, product and speeds of machinery and shafting and power charges for a given period can be reduced to hours run or horsepower-hours per department or plant unit of production.

Pipe Sizes in Exhaust Line

Where an exhaust line receives the exhaust from several engines, how is determination made of the pipe sizes between the inlets and beyond the last inlet?

J. W. H.

For a close computation of the pipe sizes it is necessary to take account of the pressure and amount of steam to be discharged per minute by each branch where it would be connected into the exhaust line and fix upon the highest back pressure to be carried beyond the last connection.

The formula for the flow of steam in pipes is,

$$W = 87\sqrt{\frac{w\,(p_1 - p_2)\,d^5}{L\left(1 + \frac{3.6}{d}\right)}}$$

where

W = Weight of steam discharged per minute;
w = Density of steam at initial pressure;
p_1 = Initial pressure, pounds per sq.in.;
p_2 = Final pressure, pounds per sq.in.;
L = Length of pipe in feet;
d = Diameter of pipe in inches.

Knowing all terms but d, its value required to satisfy the equation could be determined by trial for the different sections of the pipe.

However, in average plants such refinement of computation usually is uncalled for, since the conditions would be modified by variations in the assumed quantities of steam exhausted by the different engines. Where the sections between and beyond inlets are not over 100 ft. in length, it is sufficient to make the cross-sectional area of an exhaust line at any point equal to the sum of areas of engine-exhaust outlets connected up to the point under consideration.

Single-Eccentric Corliss Engine Cutting Off After Half-Stroke

Why cannot a single-eccentric Corliss engine be operated with cutoff later than one-half stroke?

G. H. N.

With a single eccentric the valves may be set to obtain cutoff by the admission valves after one-half stroke, but only at the expense of imperfect operation of the exhaust valves with blowing through of steam; or else admission must be made so late in the stroke that the engine can develop less rather than more power from making it possible to obtain later cutoff.

When the eccentric rod and hook rod are of such combined length that the wristplate is moved as far one side of the central mark on the wristplate stud as the other side, as indicated by the arrowheads in the diagram, and the eccentric is set 90 deg. ahead of the crank, the wristplate will be carried to the limit of its travel for a little more than one-half stroke of the piston from the head end, or for a little less than one-half stroke from the crank end. Cutoff must take place before the wristplate reaches the limit of its travel on either side of the central position or the valves will not be disengaged for cutoff during any part of the stroke.

Usually, the eccentric is set in advance of the 90 deg. position, to obtain operation of the exhaust valve with release and compression. By setting the eccentric behind the 90 deg. position and adjusting the steam valve links to obtain opening of the valves at the beginning

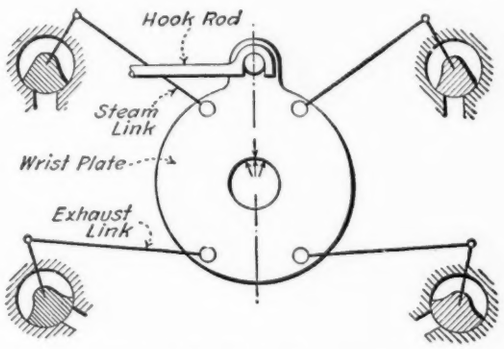


Diagram of Corliss valve connections

of the stroke and before the wristplate reaches its central position, the whole range of cutoff becomes greater than one-half stroke.

However, for setting the single eccentric behind the 90-deg. position, the exhaust valves as well as the steam valves would have to be set with negative lap in order to be opened at or before the end of an admission stroke. But neither exhaust valve would be returned to a closed position until the wristplate had been moved from one side of its central position to the end of its travel on the other side, and returned the whole distance. As this would require more than 180 deg. of rotation of the eccentric, it follows that if release by the exhaust valve occurred even so late as the end of the stroke, the same valve would not be closed again until after the beginning of a return stroke of the piston. Then, to prevent blowing through of steam admitted early in the return stroke, opening of the admission valves would have to be delayed by giving those valves more negative lap, with the result that cutting off later than half stroke, combined with the lateness of admission required, would yield less m.e.p. for the same initial pressure than if the position of the single eccentric limited the range of cutoff to one-half stroke. In a double-eccentric Corliss engine the range of cutoff of the admission valves may be greater than half stroke and there may be prompt admission without adapting the action of the steam valves to that of the exhaust valves, since each set of valves is operated by a separate eccentric.

[Correspondents sending us inquiries, should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Here and There in the Power Plant

Sidelights on things generally used but less generally understood

Enormous Forces Produced by Pipe Expansion

IT IS hard to appreciate the size of the forces that may be set up when a length of piping subject to large temperature changes is anchored rigidly at both ends. For a given set of conditions these forces can, however, be figured.

Two separate things are involved. One is the "stiffness" of the metal. The other is the rate at which the metal expands with rising temperature. Both of these properties are practically constant for all grades of steel and wrought iron, so the figures given in the present article will apply with reasonable accuracy to any power-plant piping (except, of course, piping of other materials than iron or steel).

Consider a one-inch cube of steel, Fig. 1 *A*, assumed to be at any desired temperature, say 70 deg. F. Suppose heat is applied so that the temperature of the cube rises to 71 deg., an increase of one degree. The cube will expand, although the amount will be too small to measure by any ordinary means. The actual amount of expansion will be about 0.0000065 in.—sixty-five ten millionths of an inch. This condition is represented at *B*.

Now if a compressive force is applied, the block will be shortened. There must be some force that will be just sufficient to shorten the block 0.0000065 in. so as to bring it back to

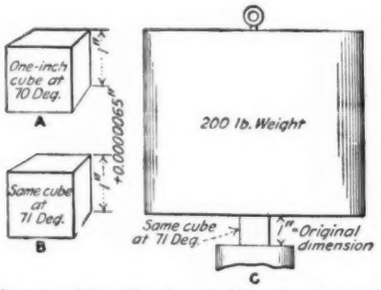


Fig. 1—If cube is rigidly held, each degree change causes 200 lb. per sq.in. stress

its original length while at the higher temperature.

This value can be closely figured by using a constant known as the *modulus of elasticity*, which for any grade of iron or steel, is practically constant at 30,000,000. This figure means that if a one-inch cube of the material is compressed or stretched with a force of one pound, its length will change one thirty millionth of an inch. It also means that if the force went right on increasing in direct proportion to the stretch, it would reach 30,000,000 lb. by the time a one-inch cube had stretched to two inches. It is important to note the *if*. Such a condition is purely imaginary, because the elastic limit will be reached by the time the block has been deformed a few thousandths of an inch. The practical point is that the tension increases at the given rate up to the elastic limit.

Now to compress the block 0.0000065 in. would require that fraction of 30,000,000 lb., giving 195 lb.—say 200 lb. for simplicity. This operation is shown at *C*. The block of *B*, still at

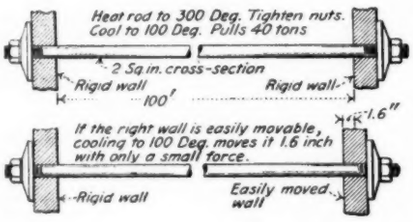

Heat rod to 300 Deg. Tighten nuts. Cool to 100 Deg. Pulls 40 tons
2 Sq.in. cross-section
Rigid wall
100'
Rigid wall
1.6"
If the right wall is easily movable, cooling to 100 Deg. moves it 1.6 inch with only a small force.
Rigid wall
Easily moved wall

Fig. 2—Cooling rod may pull forty tons or move wall 1.6 in.

71 deg., is placed under a weight of 200 lb. This brings it back to its original length.

From this it appears that if the block were rigidly clamped in such a way that expansion was impossible, a temperature rise of one degree would create a force of 200 lb. Since action and reaction are equal, this would be the force exerted by the block on the clamps and also by the clamps on the block. For any other temperature rise the force would be proportionally greater. With a 100-deg. change, for example, the force would be 100 × 200 = 20,000 lb.

This has been figured for a one-inch cube, but it holds for any length and also for any cross-section if the force is taken in pounds per square inch. For example (see Fig. 2) it may be desired to pull the walls of a building together by the old stunt of tie rods alternately heated and cooled. Such a rod is capable of exerting a pull of 200 lb. per square-inch for each degree that it is cooled. Thus a bar of two square inches cross-sectional area cooled 200 deg. (as from 300 deg. to 100 deg.) could exert a pull of 200 × 200 × 2 = 80,000 lb., or 40 tons.

Ordinarily, the walls would "give" before this tension could be reached. If the walls offered no resistance whatever, no force would be developed, the walls simply moving the same distance as the normal contraction of the rod.

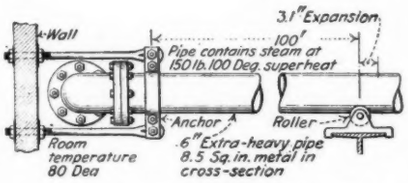


Fig. 3—It would take 328 tons to hold this pipe

For a rod 100 ft. long (1,200 in.) this would amount to 0.0000065 × 1,200 = 0.0078 in., approximately eight thousandths of an inch, for each degree temperature change. For 200 deg. temperature change the expansion would be 200 × 0.008 = 1.6 in.

Since the walls would offer some resistance, the actual condition would lie between these too extremes. That is, the force developed would be less than 40 tons and the distance moved less than 1.6 in.

The same law holds for a steam or water pipe, which is nothing but a hollow rod. Consider Fig. 3, which shows a 100-ft. section of 6-in. extra-heavy pipe anchored firmly at the left and supported freely at the right so that unrestrained expansion and contraction can take place. Starting with a cold pipe at 80 deg. F., admit steam at 150 lb., 100 deg. superheat (total temperature 466 deg.). The temperature rise is 466 — 80 = 386 deg. It has already been shown the expansion of a 100-ft. length is 0.008 in. per degree, so that admission of the steam would expand this section of pipe 386 × 0.008 = 3.1 in.

Now suppose the pipe were also rigidly anchored at the roller while steam was in the pipe. Subsequent lowering of the temperature to 80 deg. would develop a tension equal to that required to stretch the one-hundred-foot section 3.1 inches.

It has already been shown that the tension developed amounts to 200 lb. per sq.in. for each degree regardless of the length. For the 386-deg. drop it would come to 386 × 200 = 77,200 lb. per sq.in. An extra-heavy 6-in. pipe has 8½ sq.in. of metal, so the total pull would be 77,200 lb. × 8.5 = 656,200 lb., or 328 tons, assuming that the elastic limit of the metal is not exceeded.

Economy in the Use of Fuel

Philadelphia Engineers' Club Holds All-Day Conference at Which Subject Is Discussed from All Angles

Interconnection of power system, coordination between industrial and public-utility power plants, automatic regulation of boilers, use of powdered coal, education of industrial-plant executives, more intelligent operation through education of boiler-room operators, use of waste heat from industrial processes, were suggested as means of fuel economy.

AT THE Engineers' Club of Philadelphia and with Prof. R. H. Fernald, president of the club in the chair, an all-day conference was held Jan. 15, on "Economy in the Use of Fuel." At the morning session the railroads' side of the subject was discussed, in the afternoon economics in the use of fuel for power and industrial heating were considered, and at the evening session attention was given to fuels for domestic uses.

The afternoon session was opened by Morris L. Cooke, chairman of the Pennsylvania Giant-Power Survey, with a talk on the purpose of this survey, which, he said, was the unification of electric power on a large scale, in the State of Pennsylvania. Mr. Cooke pointed out that as far as that state was concerned water power was a negligible quantity on account of the vast fuel resources in the state compared with water power. In five counties there is fuel sufficient to produce power for 500 years, equivalent to Niagara Falls. Therefore, it was the speaker's opinion, although such water power as there was in the state should be developed, the one great thing to strive for was economy in the use of fuel. This survey, said Mr. Cooke, has seven objectives: (1) Supplying power from large steam stations; (2) locating these stations at or near the mines when sufficient condensing water could be found; (3) supplying the current into a 220,000-volt transmission system; (4) having a supply of power available for railway electrification so that the railroads will not have to build their own power plants; (5) working out some scheme of integrating the power supplied by the different companies into this system; (6) bringing power to the small users such as the farmers who are not close enough to the present systems to be supplied; (7) electrifying trunk-line railways.

Interconnection Results in Many Economies

N. G. Reinicker, in presenting his paper, "Fuel Economy Through Interconnection," said that interconnection of power systems reduces to a minimum the stand-by reserve and running reserve in plant capacity, and that it also reduces to a minimum the number of banked boilers necessary for safe operation. According to the speaker, the stand-by reserve capacity need not be much greater for a number of interconnected plants than for an individual plant. By proper operation, material economies can be realized from interconnection. Momentary fluctuation causes wide change of loads in individual plants that are easily absorbed in an interconnected system. Sudden falling off of load on an individual station may cause the boiler to blow, whereas a sudden increase of load on the station will cause the steam pressure to drop, resulting in a decrease in efficiency of the steam-power equipment in the station. These losses are largely avoided by interconnection.

Mr. Reinicker said that most of the troubles experienced with power-plant equipment developed at the time of starting up or after it had been running for a short while and that for this reason it was necessary in the individual plant to start machines up sooner than would be necessary otherwise. On the interconnected system the failure of a machine is not of such great moment as in the individual station, therefore the time of starting a machine up before it is actually needed on the system can be considerably reduced with a resulting economy. On the interconnected system economies can be realized on the down load curve, by shutting the machines down sooner than could be done in the individual plant without jeopardizing the continuity of the service.

Over Sundays and holidays it is possible on the interconnected system to operate with less equipment in service than in the individual plant without taking decided chances, and the load can be distributed between stations to handle it most economically. Interconnection of stations using different grades of coal also has other advantages as well as those to be gained by making it possible for co-operation among the different operating crews in an exchange of experiences. To realize these benefits to the fullest, it was the speaker's opinion, the activities of the whole system must be centered in a co-ordinating department.

Conservation of Fuel in Industrial Plants

M. D. Church, in a paper on the "Conservation of Fuel Industrial Power," said:

One very important possibility in conserving fuel is proper co-ordination between the industrial plants and the public-service company. In many cases we find industrial plants making their own power wastefully because of unfavorable location, small size of plant or improper power apparatus. In other instances we find industries purchasing all their power from a central station and at the same time putting large quantities of steam through reducing valves for use in process work, instead of developing power on the pressure drop which takes place in the reducing valve.

One of the fundamental reasons why we find such conditions is that the question of making or buying power in an industrial plant is usually considered in the light of making all power or purchasing all power. Should not the question be, what proportion of power is it advisable to make and what proportion should be purchased?

Large economical public-service plants produce a kilowatt-hour at the switchboard for 1.5 lb. of coal or less on a yearly average. The smaller and less efficient stations use up to 2.5 lb. or more.

The larger and more economical industrial plants running condensing under favorable conditions produce power as economically as most public-service plants, being in many cases favored by exceptionally good load factors. The non-condensing industrial plant, when the exhaust steam is not used and all the fuel is chargeable to power, seldom uses less than 3½ lb. of coal per kilowatt-hour and frequently much more.

However, if the heating load or the demand for low-pressure steam for cooking or process work is fairly large and it is necessary either to buy all power or make all power, the chances are that it will prove more favorable to make the power, especially if condensing water is available, so that bleeder turbines can be used. The application of these is already quite common, but there are still plenty of paper mills and textile plants where the conditions prevail now for the economical production of power in this way. This refers to condensing installations.

With non-condensing plants where the exhaust steam cannot be largely used, it will generally pay to buy power if the public-service company can supply reliable service at fair prices. When the exhaust steam can be used, however, the case becomes very different and under the conditions to be outlined, power can be generated in probably the most economical manner possible.

When high-pressure steam is reduced by being put through an engine or a turbine instead of using a reducing valve, the only heat that it gives up is the heat turned into work, plus radiation, plus the heat equivalent of the losses external to the steam spaces, such as bearing friction, flywheel windage, etc. The internal losses all convert mechanical energy into heat and the heat still remains in the exhaust.

Without assuming great accuracy, therefore, we may conservatively say that a kilowatt-hour may be produced with a reduction of not over 4,000 B.t.u. in the heat content of the steam. With a boiler efficiency of 65 per cent and coal containing 14,000 B.t.u. per lb., the coal per kilowatt-hour will be 0.44 lb. This is far less than the coal consumption of any condensing plant no matter how efficient and the reason is that no heat is rejected to the condenser.

Within reasonable limits the steam rate has small effect on the coal per kilowatt-hour, as the only factors affected are the allowances for radiation, bearing friction, etc., which are small in any normal case and are included in the approximate factor 4,000. Let us not conclude, however, that

steam rate is of no importance. The lower the steam rate the greater the power output we can obtain from a given steam flow, and power so efficiently generated should be produced in the largest possible measure.

Many plants that make all their own power at some profit can make more profit if they will buy part of their power. This is especially true of non-condensing plants, because their loss in carrying the summer load may largely offset the profit made during the winter. If they can make an arrangement with their public utility which will allow them to make as much of their own power as will give them sufficient exhaust steam for heating and purchase the balance, there will be a large fuel saving. The public utility will obtain a valuable load with a summer peak and a winter valley. The difficulty in making such arrangements at the present time seems to be for the public-utility management and the plant owner to be able to agree on how they shall share the possible savings. It is hoped that progress may be made in interconnection between industrial plants and central stations, as by this means very great fuel savings can be made.

Automatic Control of Boilers

T. A. Pebbles said that for each type of boiler plant there is a definite efficiency that should be accomplished. In the large plant this comes nearer being realized than in the smaller plant, which is largely due to paying closer attention to the station's operation in the former than in the latter. In order to maintain the proper efficiency in boiler-plant operation, it was the speaker's opinion that certain automatic devices were necessary. He said that no one would think of operating the turbines or electrical equipment without the necessary automatic devices. However, on this end of the plant not much can occur that would affect the efficiency of the plant when in good operating condition, but in a boiler plant the efficiency can vary over wide ranges in a very short period owing to changes in operating conditions.

When we speak of automatic devices for the boiler room, said Mr. Pebbles, we do not have in mind something to replace the fireman, but something that can perform some of the functions that can be done better automatically than by hand. Automatic control can make the boilers respond immediately to a change in load, can control the supply of fuel and air to the furnace, and control the air pressure to correspond to the resistance of the fire, but it cannot take care of clinkers on the side walls. Changes in the grade of coal, changes in the moisture content in the fuel, holes in the fire are conditions to be taken care of by the fireman. However, automatic control would do a lot toward correcting for them. A change of 5 or 6 per cent in the moisture content of the fuel might cause a stoker to feed 10 per cent more coal for the same speed. When the load starts to change with the boiler under automatic control, the operator does not have to worry about this, but can devote his attention to making minor adjustments to keep the plant up to the highest efficiency. The speaker told of one case where with automatic control on boilers burning blast-furnace gas, the pressure of which varied over wide range, it was possible to obtain 24 per cent CO_2, 1 per cent O and no CO in the flue gases.

Education of Executives

F. F. Coffin expressed the opinion that much could be done in the way of fuel economy by educating the executives in the small and medium-sized industrial plants to a realization of its importance. He said that since in many industries the cost of power represented only about 3 to 5 per cent of the cost of production the executives were inclined to give little attention to this part of the business. He suggested the formation of a committee for the purpose of interesting them in fuel economy by better operating methods in their power plants.

Powdered-Coal Equipment

H. D. Savage said that last year contracts were placed in this country for powdered-coal equipment for use on boilers having an aggregate of 1,300,000 sq.ft. of heating surface. He said that one of the features of powdered-coal equipment was its ability to burn efficiently all kinds and grades of coal that might come to the plant; that at the River Rouge plant of the Ford Motor Co., powdered coal, oil, blast-furnace gas and coke-oven gas have been burned in the same furnace at the same time; around coal mines powdered-coal equipment is being installed to burn bone coal and other unmarketable grades. Mr. Savage pointed out that with powdered coal it is possible to obtain higher ratings from the boiler at higher efficiencies than by any other methods of firing. Contrary to what is generally thought, the temperatures on the furnace walls are not very high, being about 1,500 deg. F. against about 2,700 deg. F. in the center of the furnace. In answer to a question regarding the difficulties with ashes being deposited on the surrounding country when burning powdered coal, the speaker said that on paper a case could be made out against powdered coal, but in practice the area over which these ashes were deposited was so great that they never would cause any trouble, and he did not anticipate any difficulty from this source within metropolitan districts.

Advantages of Intelligent Operation

H. H. Norton, Lt. Com. U. S. N., in a paper, "Economy of Fuel Through Intelligent Operation," said that the Navy is an organization that recognizes the advantages of intelligent operation and he laid great stress on this factor as a means of improving boiler efficiency. Shortly after oil burning was adopted for the Navy's boilers, it was realized that there was a considerable difference between the boiler efficiencies obtained on test and those obtained in practice. This was considered to be due to the lack of proper knowledge on the part of the attendants and led to the establishment of a school for the training of boiler-room operators. Since the starting of the school the average efficiency of boilers in the navy has increased 10 per cent. Because the boiler efficiencies obtained in practice are away below those under test conditions, the Shipping Board is also sending its boiler-room operators to the Navy school, with a resultant increase in boiler efficiency.

Progress in Steel-Plant Fuel Economy

Hugh L. Freyn presented a comprehensive paper on "Recent Progress in Steel-Plant Fuel Economy." He expressed the opinion that with a properly laid out blast-furnace and steel plant the only coal required should be for the coke ovens, the additional heat for process and power purposes being produced from the gases and waste heat from the different processes. He pointed out that one ton of finished product should be produced on 1.3 tons of coal, where in this country about 2.6 tons were used. In Europe about one ton of steel is produced on 1.38 tons of coal.

In discussing the large gas engines operating on blast-furnace gas, he said that more grief had been experienced with it than any other piece of equipment in the steel mill. After the first large gas-engine plant was started in this country, it was necessary to clean out the gas passages and cylinder every 10 to 12 hours. This difficulty was overcome by washing the gas, something that was not thought of at first. The speaker said that a single-tandem gas engine of 6,000 hp. was in operation in Europe. This size made it possible to construct a double tandem engine of 12,000 hp. In his opinion the gas turbine is beginning to show possibilities; there has been a 5,000-hp. unit constructed in Europe. Gas-engine waste-heat boilers offer possibilities as coal savers in steel plants.

Fuel Economy in Cement Mills

H. A. Schaffer told of the work done by the conservation bureau of the Portland Cement Association. He said that when the bureau was formed five years ago only 8 cement mills were equipped with waste-heat boilers on the kilns and only 5 of these were modern plants. Today there are 35 plants in operation and 8 more are under construction. This has resulted in reducing the coal consumption per barrel of cement from 60 to 30 lb. A saving of 4.5 lb. of coal per barrel of cement has been obtained by heat insulating the kilns in addition to the firebrick lining. Recovery of the heat from the clinkers, which have a temperature of about 2,100 deg. F. as they come from the kiln, by reheating the combustion air would result in a fuel saving of 7 to 8 per cent. The speaker predicted that when all the mills in the association were equipped with waste-heat boilers and other heat-saving refinements, it would result in a fuel saving of 2,000,000 tons per year.

Chicago A.S.M.E. Holds Power Meeting

AN ALL-DAY power meeting of the Chicago Section of the American Society of Mechanical Engineers on Jan. 15 consisted of a series of seven papers devoted in the morning to the power plant as a whole and in the afternoon to the different types of coal-burning equipment. In the evening a banquet was tendered to the President of the Society, Fred R. Low.

Central Station Power Plant

The first paper, "The Central Station Power Plant," presented by P. W. Thompson, of the Detroit Edison Co., in behalf of C. F. Hirshfeld, dealt with the numerous changes in the last decade that have upset former practice in power-plant design and operation. The author said that during the last ten years the price of coal has more than doubled and it is probable that the price is up to stay, for which due consideration must be given in the design of a power plant. Ten years ago the cost of coal represented approximately one-half of the operating cost; today this percentage has increased to 75. Labor also has increased but not in the same proportion and the same statement applies to the net cost of power in spite of the increased cost of coal and labor.

As to the things that might be done to decrease the cost of power, a labor-saving could be effected by the use of larger units. But this would be relatively small, leaving coal as the main item to consider.

In the central station generally the character of the load has changed. Power forms a larger proportion of it, and with operation day and night it is spreading out more uniformly over the 24 hours, giving a higher load factor and reducing the overhead charges per unit.

Higher Thermal Efficiency Justifies Greater Investment

Owing to the increasing cost of production and the higher load factor, greater investment is permissible in an attempt to secure higher thermal efficiency. At the present time many different types of plants of improved design are being built; in fact the whole art of power-plant design is in a state of flux, so that more should be known about the results possible in the early future.

The paper stated that efforts to obtain higher efficiency are being directed along two definite lines—one in the boiler room and the other toward improving cycle efficiency. In the boiler room there are four different plans of procedure. In the older plants with relatively high load factor, economizers are being installed. A conservative estimate of the improvements effected in economy is about 5 to 7 per cent. The second plan is to install air preheaters in both the older and the newer types of plant. A gain of 5 per cent or more is possible, but it is difficult to say how far this movement will proceed. In the last year or two the use of pulverized fuel has been given a great impetus, and it is gaining in favor rapidly. Other factors influencing economy are the use of more highly developed stokers, special settings and the proper cooling of refractories by air, steam or water to reduce the cost of maintenance. How this cooling effects economy is not so well known.

Higher Temperatures and Pressures in the Turbine Room

In the turbine room designers are going to higher temperatures and pressures. Limitations of present metals limit this movement to temperatures of 725 to 750 deg. F., which already has been reached in some of the later plants. How much higher temperatures may go is problematical.

Relative to higher steam pressure there are three schools of thought: Those who believe in limiting pressures to the vicinity of 300 lb., those favoring 500 to 600 lb., and those who are reaching out toward pressures of 1,100 to 1,200 lb. The use of pressures of 500 lb. and up requires reheating to prevent water being thrown out of the steam during expansion. This reheating introduces so many complications that conservative engineers are doubting its advisability.

The greatest change in cycle efficiency has been brought about by stage bleeding involving motor drives for the auxiliaries with perhaps certain steam-driven units in reserve. As the number of stages of bleeding increases, this method approaches the regenerative cycle, and this is the cycle having the greatest thermal efficiency. The number of stages of bleeding to employ is a problem for each installation. From one to four stages are being used, depending upon the character of the load and the location of the plant.

Today the best plants are producing a kilowatt-hour on 18,000 to 19,000 B.t.u. Newer plants are being constructed with a probable heat consumption of 16,000 B.t.u., and it may be possible to go lower, as right now a plant may be laid down on paper that will figure to produce a kilowatt-hour on 14,000 B.t.u.

Importance of Continuity of Service

While favoring improvements to better economy, Alex Bailey, of the Commonwealth Edison Co., emphasized the importance of continuity of service, as reliability was the big thing demanded by the customer. There was the danger of making plants too complicated. In their plants in the last 15 years expenditures for coal had risen from 56 to 84 per cent of the operating cost, pounds of coal per kilowatt-hour had been reduced from 7 or 8 to 1.8 lb., and the cost of the coal had increased from $1 to $4.50 per ton. There had not been a great change in the labor. Coal, forming 84 per cent of the operating cost, was the big thing and their hope for greater economy lay in stage bleeding.

John Anderson, of Milwaukee, had had some experience with radiant superheaters and they had shown great beneficial effects on the refractories. He felt strongly that the new things had to come, and that it is up to the engineer to get busy and make the new features reliable. The movement might be slow and possibly take ten years before it would be feasible to get all that was possible out of the higher pressures.

Power Generation in the Modern Steel Plant

As an example of what may be done in an industrial plant toward improving economy by the recovery of byproducts and the utilization of waste heat, the second paper of the morning session on "Power Generation in the Modern Steel Plant," by G. R. McDermott, assistant chief engineer of the Illinois Steel Company, was most instructive. One of the features of the paper was an outline of the new blast-furnace gas-engine plant at the works in which an average efficiency of 24 per cent is being maintained. Another point of interest was the boiler that had been designed to utilize the heat in the exhaust from these engines. This paper will be represented more fully in a later issue.

In the discussion Prof. E. F. Gebhardt pointed out that where it is possible to utilize the heat in waste gases or steam, economy in the isolated plants would far exceed that obtainable in the central station. He said that a Diesel engine installation utilizing the jacket water for feed-water heating and the exhaust gases to make steam, had shown an over-all economy of 72 per cent. At the afternoon session there was an overflow attendance to listen to the five papers on the program. In the first paper, on "Heat Transfer Through Turbulent Gas Flow," Lloyd R. Stowe proved in a most interesting way that in economizers on the later passes of a boiler the problem is not one of transferring heat from the gas to the tube, but of dispersing heat equally through the gas itself. It is not possible to disperse this heat by the convection of gases as induced by a difference in their densities nor by the conduction of heat through gases, for both of these methods operate too slowly. Since a particle of gas is cooled from, say, 2,000 deg. F. to 600 deg. F. in less than a second of time, the heat must be dispersed through the cross-sections of heating surface with great rapidity. It

is carried about on the turbulence of flow, and the problem of design is to stimulate this turbulence and increase its effectiveness. Two things have been established about gas flow and turbulence. The first is that the linear velocities of gas flow are higher in the center or core of the stream than the velocities adjacent the walls of the stream. The second is that an increase in average linear velocities increases the effectiveness of turbulence. A material part of the paper was devoted to the development of the two simple rules following:

First, arrange that all the gas flows close to the tube through the use of small gas streams.

Second, use the minimum number of such streams.

Underfeed Stokers and Their Use with Middle-West Coal

The other four papers of the session were devoted to fuel-burning equipment, two dealing with stokers and two with pulverized coal. In his paper on "Underfeed Stokers and Their Use with Middle West Coal," Joe Worker, president of the Stoker Manufacturers' Association, presented the following interesting figures to prove the wide use of underfeed stokers: In 1922 about 1,000,000 hp. in boilers were sold. Of this total 800,000 hp. were equipped with stokers as follows: 550,000 hp. in underfeed stokers, 200,000 hp. in chain grates, and 50,000 hp. in overfeed stokers. For Middle West coal more underfeed stokers were being used than any other type and there were nearly as many underfeed stokers being sold in the West as in the East. Slides were presented to illustrate the principles involved in the fuel bed of the underfeed stoker, showing the arches of fuel supporting the fuel bed, the gravity feed of the ash down an incline, the development work that had been done to keep the ash from sticking to the side walls, and at the bridge wall the use of air and water backs and the rotary ash discharge.

Fred Lass, of Denver, referred to the successful burning of lignite on underfeed stokers. He had had no trouble with clinkers, but owing to the light ash from the fuel in this territory it was necessary to limit the wind-box pressure to 2 in. of water. The lignite was crushed to the same size as for the chain grates in the plant.

Papers on Pulverized Coal

Henry Kreisinger, in his paper on pulverized fuel, limited his remarks to the boiler furnace. In his opinion a properly designed furnace has the following five requirements: It must burn the coal completely with little excess air; the furnace must stand the high temperature; the furnace must be designed so that the ashes may be removed without taking the boiler out of service; the fuel must be ignited easily and the unit quickly brought up to the desired rating; the installation must be safe. Briefly, the rate of combustion should not exceed 25,000 to 30,000 B.t.u. per cubic foot of furnace volume per hour, and when this volume is attained the combustion space should be arranged to give a flame travel ranging from 40 to 65 ft. A long flame travel made it possible to burn coal of less fineness, 65 per cent through a 100-mesh screen being good enough.

The paper by Ralph Galt, of the Fuller Engineering Co., on the "Burning of Waste Coal in Pulverized Form Under Boilers," was read by H. Reichenbach. The author reviewed what had been accomplished in the burning of the waste fuels on the Pacific Coast, anthracite culm in Pennsylvania, the middle products from coal washeries, bone coal from the mines, coke braize, etc. Numerous slides showed the types of plant employed and the construction features of Fuller equipment.

Discussion

In the discussion on the powdered-coal papers, it was pointed out that a combustion rate higher than 25,000 to 30,000 B.t.u. per cu.ft. of furnace volume could not be employed without destroying the furnace walls. Water screens helped in this direction, but were costly to install. In the locomotive, with its comparatively small firebox, combustion rates up to 50,000 B.t.u. per cu.ft. had been attempted, but did not prove very successful. In furnaces with short flame travel it was necessary to use more burners and reduce the feed of each and the length of the flame. Another essential of short flame travel was the use of high-grade volatile coal that would ignite and burn quickly.

Forced-Draft Chain-Grate Stokers

In the final paper on forced-draft chain-grate stokers by J. Van Brunt, chief engineer of the Combustion Engineering Corporation, the development of the Coxe stoker for anthracite and later for bituminous coal was reviewed and accompanied by some interesting data on performance, furnace proportions and designs of numerous installations. Slides showing the construction of the different makes of forced-draft chain grates in this country and England added to the interest of the paper.

In the evening the banquet at the Hamilton Club was an enjoyable affair. President Low talked of the purposes, needs and opportunities of the Society, with special reference to the increase in dues and a comparison of costs at the present time and ten years ago for the various services rendered to the members. He pointed out what the engineer might be if he would take a leading part in the big industrial reorganization that must come in this country. A happy conclusion to the long day of technical considerations was a half-hour of humorous anecdotes and readings in the French-Canadian dialect by W. B. Amsbary, professor of literature at Armour Institute. The professor is an adept in this form of entertainment, and his stories were greatly enjoyed.

Outline of Engineer's Coal Storage Report

The American Engineering Council's report on coal storage will be made public about Feb. 1. Dean J. F. Walker, of the University of Kansas, submitted the following outline of the report at the recent meeting of the Council:

The committee charged with the investigation presented a report of progress at the meeting of the Executive Board of the Council.

The report is now being drafted into final form. A great amount of data has been accumulated, bearing upon:

Methods of storage; cost of storage; practice in storing and handling coal on the part of public utilities, manufacturing industries, the railroads, coal dealers, public institutions, departments of the government and other coal users, and present conditions as to stocks carried, in co-operation with the United States fuel Administrator; production and transportation of coal; lost time and overdevelopment in the bituminous coal-producing industry.

In dealing with these data and formulating the report, it has been decided to treat of the conditions in different sections of the country separately. Requirements and the conditions influencing distribution differ so radically in various sections that no single remedy for existing ills can be devised. Local needs must be fully understood before remedial action can be considered.

Sections of the report will be devoted to the Great Lakes traffic and the storage facilities at the Lake Superior docks; to the conditions of supply and distribution in New England; to conditions in the various local communities; to the needs and practices of industries by groups; to special transportation conditions, including differences in the cost of transportation under summer and winter conditions; and to methods and costs of storage. The aim is to give reliable answers to certain questions which those concerned with coal supply will ask when confronted with the problem of adjusting coal demands to a more uniform rate of production; namely, How much storage is necessary to produce desirable results in the coal industry? What methods of storage are best adapted to the situation? What will it cost to store the coal? What purchasing policy is best? What are the advantages coming from a coal-purchasing policy that insures regular supply and a continuous producing program in the individual plant that warrants the expense of storing a limited portion of the year's supply of fuel?

The French Senate has agreed to provide sufficient funds to build dams and to install turbines in the Department of Finistère to harness the tides and produce electric power. There is a heavy rise and fall of the tide in this part. One dam 450 ft. long is in the river mouth and has three turbines, from which it is believed that 3,600 hp. will be developed.

Two miles inland a second dam in the river, 105 ft. high, gives a fall to the water at all times. This turbine will generate 4,000 hp. The annual production is estimated at 11,000,000 kw.-hr., and the cost of construction is estimated at about 30,000,000 francs.

Power Companies' Offer for Muscle Shoals Reopens Issue

HEARINGS have been resumed in Washington before the House Military Affairs Committee, on the various bills which seek to dispose of the government's war-time nitrate and power project at Muscle Shoals, Ala. One of the most bitter fights in the history of Congress is in sight in connection with this measure. Many members regard Muscle Shoals as a fertilizer and an "aid-to-the-farmer" matter, not a power matter. Many of them are pledged to the Ford proposals.

The principal feature at the opening of the hearings was the position taken by Representative J. Mayhew Wainwright, of New York, former Assistant Secretary of War, a new member of Congress and of the Committee, who intends to take an active part in the solution of Muscle Shoals' problems. He announced at the hearings that new bids should be asked for, to obtain the highest possible offer and best guarantees, and asked that a sub-committee of the Military Affairs Committee should be named to confer with the President, in regard to the President's recommendations in his message advising the appointment of a small committee or joint commission, under general legislation, to deal with Muscle Shoals.

Favors Ford Offer

Representative Madden, of Illinois, chairman of the House Appropriations Committee, was heard, on his bill, and advocated the acceptance of the so-called Ford offer. Giving figures he used in a speech made by him last year, he recited the tremendous sums spent by the government, and to be spent, denounced the idea of government ownership and operation, and made it plain he desires Congress to get rid of Muscle Shoals, preferably to Henry Ford. Mr. Madden's bill provides for building a power plant and transmission line for Mr. Ford, to take the place of the Gorgas plant and lines sold to the Alabama Power Co. last summer. That is not acceptable to a majority of the Committee, and House leaders say they will never be put in the position of urging and placating Mr. Ford in regard to Muscle Shoals. Representative Garrett, of Tennessee, the (Democratic) minority leader of the House, was also heard and declared for the so-called Ford offer on the ground of aiding the farmer with cheap fertilizer.

It developed at the opening of the hearings that nothing has been heard by members of Congress from Mr. Ford in any authoritative way as to whether he still wants Muscle Shoals, or whether he would accept any of the bills now before Congress, Mr. Ford having previously declared in a formal letter he would not accept Muscle Shoals without the Gorgas plant. Representative McKenzie, of Illinois, has been trying to obtain some statement from Mr. Ford on this subject, without success at the time this is written, and the Committee may require the Ford representatives to appear. Mr. McKenzie's bill, now before the Committee, is a pro-Ford bill, but he is frankly anxious to have the Ford representatives say if his measure is satisfactory before he tries to report it out.

Power Companies To Be Heard

Thomas W. Martin, president of the Alabama Power Co., and representatives of a group of other Southern power companies, were present at the hearings, prepared to testify, if desired, upon the joint letter they recently sent to the Federal Power Commission, on the initiative of Representative Harry E. Hull, of Iowa, stating that they would pay $100,000,000 for a fifty-year lease at Muscle Shoals under the Federal Water Power Act. They will be heard by the Committee. The Committee will also go into the bill introduced by Representative Dickinson, of Iowa, a member of the House Steering Committee, and the leader in the House of the Farm Bloc, which would place Muscle Shoals under the Federal Water Power Act, irrespective of who leases or buys the plants and water power rights. One of the witnesses on this bill, in addition to Mr. Merrill, will be Dr. Cottrell, of the Fixed Nitrogen Research Laboratory of the Department of Agriculture, at the request of the Secretary of Agriculture. It is understood that this bill is the Agricultural Department measure, and drawn there. It is also understood that the Secretary of War hopes soon to send to the Congress a fertilizer offer he is expecting to receive from the Union Carbide Co., and it is also expected that there will soon be made public and sent to Congress an offer to manufacture fertilizer in coincidence with the 100,000 hp. reserved for fertilizer manufacture in the letter of the associated southern power companies, made public last week.

As the hearings began in the House Committee, Senator McKellar, of Tennessee, and Senator Heflin of Alabama, both pro-Ford and both violently anti-Alabama Power Co., delivered on the floor of the Senate, an attack on the power company, charging that its securities are 70 per cent British-owned. They charged that such a situation would be dangerous to the United States in time of war and that it would be unwise to turn Muscle Shoals over to anyone except Henry Ford without requiring that the ownership of any corporation operating Muscle Shoals should remain American. Senator McKellar and Senator Heflin were answered by Senator Norris, of Nebraska, chairman of the Senate Committee on Agriculture and Forestry, who said that such a provision could be made in any bill accepting an offer for Muscle Shoals. He pointed out that no one could know who would eventually own Mr. Ford's proposed Muscle Shoals corporation. It appeared that Senator Norris has not altered his opposition to the Ford proposals made evident in the last Congress.

Coincidentally, speakers at the annual meeting of the Public Ownership League, being held in Washington, delivered similar attacks on the Alabama Power Co.; and Gray Silver, Washington Legislative Representative of the American Farm Bureau Federation, made public various statements and letters, supporting the so-called Ford offer and attacking the power company, as well as Secretary Weeks for selling the Gorgas plant to the power company.

What will come out of the fight in Congress no one may safely predict.

Shipping Board Wants Diesel Engines Installed

Legislation authorizing the United States Shipping Board to allocate $10,000,000 of its construction fund to a special fund to be used in installing internal-combustion engines and auxiliary apparatus in Shipping Board vessels and in lending money to private ship-owners for the same purpose will be recommended by the House committee on merchant marine and fisheries.

The money is to come from receipts from sales of vessels which, under the Jones act, are being placed in a special construction fund for five years. This fund now contains $75,000,000. The future of the seas, particularly as applies to cargo vessels on long routes, belongs to ships with Diesel type motive power, Admiral Benson told the

committee. Because of its experience and its observation, the Board desires to equip 50 vessels with these engines and to encourage private owners to convert their ships likewise, he asserted.

Unless the American merchant marine is equipped with the Diesel type of motive power, it soon will be outdistanced by foreign competitors, the committee was told.

The Shipping Board introduced a statement showing that on a cargo ship of 8,500 deadweight tons, operation by the internal-combustion engines would save $9,960 a year as compared with a coal burner and $3,496 a year as compared with an oil burner in personnel alone.

A ship equipped with Diesel-type engines can go on a long route and return without refilling its fuel tanks, whereas either a coal burner or an oil burner would have to take on supplies before returning, the committee was told. Increased speed is one of the principal factors in favor of the conversion.

Would Create New Commission

The Public Ownership League, which held a Superpower Conference in Washington, D. C., Jan. 16-17, has adopted as its slogan, "Public Superpower for Service as Against Superpower for Profit." The creation of a Public Service Commission with power to take over the authority and functions of the Reclamation Service and the Federal Power Commission was advocated and that it be specifically authorized to develop the Muscle Shoals properties as a part of a "public superpower system" was also proposed. A bond issue of $500,000,000 was also indorsed to provide a revolving fund for federal aid to states and cities in development of public superpower systems.

F.A.E.S. Changes Its Name and Constitution

At the meeting of the American Engineering Council the legislative body of the Federated American Engineering Societies a constitution was adopted which changed the name of the society and also its organization.

The American Engineering Council is the name of the aggregated societies, and the management of the Council is vested in a body of representatives to be known as the General Assembly, and an Administration Board, the General Assembly to consist of representatives of member societies. Each national, local, state and regional organization and affiliation to be entitled to one representative on the General Assembly for membership of from one hundred to one thousand inclusive and one each for each additional thousand or the major fraction thereof.

The administrative Board of the Council is constituted and charged with conducting the business of the organization under the direction of the General Assembly and acting for it when the Assembly is not in session and is to consist of not to exceed thirty members, of whom six shall be elected officers of the Council and the remainder shall be selected, a part by the national societies and the rest by the local, state and regional organizations.

No decisions affecting the policy or action of the American Engineering Council can be made by the General Assembly or the Administration Board unless it shall receive a two-thirds affirmative vote: of the representatives present of each national member societies, having six or more representatives on the Assembly; of the aggregate of the representatives present of the other national member societies; of the aggregate of the representatives present of the local, state and regional member societies. These limitations do not apply to the election of officers, the eligibility of representatives, the admission of members, the determination of assessments, the payment of bills, the adoption of a budget, the amendment of the by-laws or the rules, the selection of a place and time for a subsequent meeting, of matters of purely routine nature.

James Hartness
President American Engineering Council

A representative on the General Assembly or the Administration Board must have been in active practice as an engineer or allied technician for not less than six years and shall have had responsible charge of work as principal or assistant for not less than two years. The elected officers of the Council to consist of a president to hold office for two years, four vice-presidents to hold office for two years and a treasurer to hold office for one year.

Ontario Hydro Commission May Develop St. Lawrence

Sir Adam Beck, chairman of the Ontario Hydro-electric Power Commission, has laid before the Canadian federal government a proposal for St. Lawrence power development. The scheme includes a dam, control works and power house at Morrisburg, Ontario, to cost between $75,000,000 and $80,000,000. As this is an international power site New York State would be expected to bear half the expense and would receive half of the 350,000 hp. developed. The plan calls for the Canadian federal government to pay $15,000,000 of Ontario's share of the cost of the project in compensation for the water control facilities.

Sir Adam Beck also proposes the construction of a high voltage line from Ottawa to Morrisburg and from one of these points to Toronto in order to tie up the St. Lawrence system with the Niagara system and to tie in the future developments of the Ottawa River which will produce from 300,000 to 400,000 hp.

The Ontario Hydro-electric Power Commission also expects to ask the Ontario government for an appropriation of from $10,000,000 to $12,000,000 to install a large steam plant on Lake Ontario or Lake Erie to augment the Niagara system in carrying peak loads.

Prof. H. T. Barnes, former director of physics in McGill University is now aboard a Canadian government steamer studying ice conditions in the St. Lawrence. He says that the St. Lawrence can be cleared of ice, that the entire St. Lawrence must be converted into a ship canal and that the development of the hydro-electric power would pay for it.

Museum of Safety Opened in New York City

The American Museum of Safety, which was closed during the war, was re-opened on Jan. 16 at 120 East Twenty-eighth Street, New York City. The museum is maintained by a corporation of which Arthur Williams is president. Its purpose is the prevention of injuries and loss of life and the elimination of hazards to industrial workers and the public generally. Devices used by railroads, industrial plants and mines to prevent accidents are shown. Announcement of a gold medal to be given by the Scientific American for the best safety device exhibited during the year was made.

Exposition of Water Power in France in 1925

M. Le Trocquer, Minister of Public Works, France, has announced that he will demand government credits of three million francs for the country's participation in the exposition of the hydraulic and allied industries which is to be held from May to October in 1925.

An equal sum will be granted by the departmental governments of the district, actually those counties which made up the former provinces of Dauphiny and Savoy in the French Alps where the most important hydraulic installations of France have been constructed to date. Finally, there is to be a government authorized lottery of nine million francs in prizes, which will produce another five million francs for

the organizers, in all eleven million francs.

This is considered as offering the possibilities of the most grandiose manifestation on behalf of this industry which has been made to date by any country.

Give Japs Your Back Files of Engineering Papers

As a result of the recent fire and earthquake in Japan the Japanese engineers have lost much engineering data and material, especially back files of engineering papers. If readers of *Power* have such material for which they have no particular use and would be willing to send it to the McGraw-Hill Co., Inc., Tenth Ave. at Thirty-sixth St., New York City, the publishers will undertake to forward it to the engineering societies of Japan.

Great Falls Development Planned

To bring before Congress the problem of hydro-electric developments of Great Falls, situated near Washington, D. C., to provide light, heat and power for the City of Washington, government departments and local industries, a resolution has been introduced into Congress by Fred N. Zihlan, republican representative, of Maryland and R. Walton Moore, democrat, of Virginia. The resolution provides for the appointment of a commission to study closely the report of Major M. C. Tyler, which has been indorsed by the Federal Power Commission and by the Board of Engineers for Rivers and Harbors Works of the War Department.

The report calls for two power dams at Chain Bridge and Great Falls and three storage reservoirs—Great Cacapon reservoir, North Fork of Shenandoah reservoir and South Branch of Potomac reservoir.

Increased Production of Coal and Coke in 1923

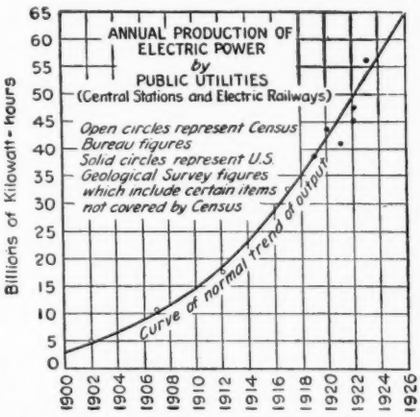
The production of bituminous coal, according to the Bureau of Domestic and Foreign Commerce, for the year 1923 is 545,300,000 tons. This shows a greater production than any year since 1920, when 568,667,000 tons was produced. Anthracite production was 95,500,000 net tons, which is a greater production than any year since 1918, the record year, when 98,826,000 tons was the production. These figures are estimated and are subject to a slight revision.

The combined production of beehive and byproduct coke was about 55,487,000 tons, an amount almost equal to that of 1917 and only 1.8 per cent less than the record set in the war year, 1918, according to the Geological Survey.

The Federal Trade Commission, in a current report, states that wholesalers' reports for the two weeks ending Dec. 15, covering only premium coal of domestic and pea sizes, show a marked decrease in the proportion of anthracite on which a gross profit of 50 cents or more per ton was obtained. Although gross profits ranging up to $1.75 per ton are still being realized by some wholesalers on a very small part of the tonnage handled, and the passing of anthracite through the hands of two or more wholesalers still tends to enhance the prices of a part of the anthracite handled by wholesalers, the main cause of high prices charged the consumer continues to be the premiums exacted at the mines by producers of a comparatively small proportion of the total anthracite output.

Electric Power Production as Barometer

Electric power production constitutes one of the most sensitive and valuable of business barometers, said Dr. George Otis Smith, Director of the United States Geological Survey, in the course of an address made before the American Statistical Association. "In the first place," said Dr. Smith, "electric power faithfully reflects all business and the per cent of it which is used for lighting gives a not disproportionate weight to its domestic use. The curve is nowhere distorted by storage."



Growth of electric power production by central stations, 1902 to 1923. Data from census and Geological Survey. Trend determined by A. H. Horton

Domestic Production and Consumption of Oil

In the year 1923 the domestic production and consumption of crude oil and of refined gasoline broke all previous records. The estimates of the American Petroleum Institute are: Domestic gross crude oil production, 745,000,000 bbl., an increase of 187,000,000 bbl., or 33.6 per cent over 1922; imports of crude oil, 80,000,000 bbl., a decrease of 30,000,000 bbl., or 27.3 per cent; total domestic production and imports of crude oil, 825,000,000 bbl., an increase of 157,000,000 bbl., or 23.6 per cent over 1922; consumption, including exports, 730,000,000 bbl., an increase of 154,000,000 bbl., or 26.7 per cent over 1922.

On Jan. 1, 1924 approximately 327,000,000 bbl. of crude oil was on hand in pipe-line and tank-farm storage and 138,000,000 bbl. of crude and refined products at refineries, a combined total of 465,000,000 bbl., or an increase of 93,000,000 bbl. during the year 1923. Doubtless also a comparatively small amount of stocks accumulated in producers' tanks, figures for which are not yet available.

Bay of Fundy Tide To Be Used To Develop Power

The first application to reach the Federal Power Commission proposing any development of power by using the tide just has been filed by Dexter P. Cooper. Mr. Cooper is a brother of Hugh L. Cooper. His application covers a project on the Bay of Fundy, near Eastport, Maine, calculated to develop some 400,000 hp.

The project involves the construction of five miles of dams which will connect the mainland with Deer and Porto Bello Islands and cross Lubeck Channel to the mainland of Maine. The power house is to be constructed between two pools which will be created by the dams. The range of the tide at this point is in excess of 30 ft. By the operation of these pools, Mr. Cooper calculates that a flow of some 200,000 cu.ft.-sec. can be obtained, and that a head varying from 16 to 27 ft. can be secured.

Hetch-Hetchy Power Project Awaits Plan

The City of San Francisco has decided against the proposed immediate appraisal of private power systems for a municipal distribution system. Action by the board of supervisors has been delayed for eight weeks. A resolution of the board asks the joint finance and public utilities committees to formulate a plan by Jan. 21 for the development of the Hetch-Hetchy water project to safeguard the city's water rights and at the same time promote ultimate development and distribution of power, municipally owned. This plan, it is expected, will be submitted to the voters for ratification. The referendum vote will serve as a needed guide in determining the policy of the city in these two costly interlocking plans.

The Hetch-Hetchy proposal, in the Yosemite, 156 miles distant, was agitated primarily to insure San Francisco a perpetual adequate water supply at a lowered rate—hydro-electric power was considered a byproduct; but with the completion of the dam a potential power supply has become available which many believe should be utilized immediately.

The Raker Act is advanced as argument against its disposal temporarily to private companies for resale and distribution and the alternative of a quick plunge into municipal ownership by purchase of appraised private companies. Additional construction is advocated. The power companies have agreed to pay $2,000,000 annually to the city during the time required to

complete the Hetch-Hetchy system. No faction seriously considers an independent municipal company in a competitive field.

It is generally understood that nothing prevents the city from employing a power company as the city's agent to distribute electric energy in the Hetch-Hetchy project, and no violation of the spirit of the act in a distribution of power made through privately owned channels.

Program of Spring Meeting of A.I.E.E. Planned

Some of the papers planned for the Spring Meeting of the A.I.E.E. which is to be held in Birmingham, Ala., April 7 to 11, are as follows:

"High-Tension Oil Circuit Breaker Tests," by representatives of the Alabama Power Co., General Electric Co. and the Westinghouse Co.; "Operation of Systems with Hydro and Steam Plants," by N. G. Reinicker, Penn Power & Light Co.; "Maximum Demand Regulator," by E. T. Moore, Halcombe Steel Co.; "Analysis of Water-Power Resources of the South and Recommendations for Development," by C. O. Lentz, consulting engineer; "Hydro-Electric Practices and Equipment," by R. H. Johnson, electrical designer; "Hydro-Electric Practices and Equipment on the Pacific Coast," by S. Barfoed, consulting engineer; "Acceptance Tests for Hydro-Electric Plants," by F. H. Rogers, William Cramp & Co.; "Hydro-Electric Design and Practice in the South," by O. G. Thurlow, Alabama Power Co.; "Effect of Certain Impurities in Storage Battery Electrolyte," by G. W. Vinal and Mr. Altrup, of the Bureau of Standards; "New Synchronous Induction Motor," by Val A. Fynn, consulting engineer; "Lightning Arresters," by C. E. Bennett, Georgia Railway & Power Co.

Smith Condemns Maine Law Against Power Export

George Otis Smith, Director of the Geological Survey, has issued a series of open letters addressed to Charles E. Gurney, Chairman of the Public Utilities Commission of Maine. Some of the pertinent points brought out by this expert of the natural resources of the United States, who is also a citizen of Maine, show that he has studied this question of how to bring about larger use of the energy in the flowing water of Maine's rivers. He states that the figures published by Maine Commission show that regulation by means of storage would add only 84,000 hp. to the sites already developed, yet on three western rivers, the Saco, Androscoggin and Kennebec, there are unused sites that would yield 85,000 hp. without storage while waiting for a state storage-reservoir plan.

About the superpower plan he states:

The superpower plan simply contemplates the largest possible utilization of the water powers of several states by harnessing up these natural sources of energy with large steam-power stations. Let me first of all assure you that the engineers who worked out the details of this plan for the government at no time had "covetous eyes on the water-power of Maine," as has been asserted. As the federal official in direct charge of the superpower engineering study I know whereof I speak, so that my denial of intent may be taken as authoritive. The superpower report published in 1921 as Professional Paper 123 of the United States Geological Survey makes brief mention of the undeveloped water-power resources in Maine, but adds: "As hydro-electric energy generated in Maine cannot, under the present laws of this favored coal to Maine and other its boundaries, these potential developments have not been analyzed in detail."

Mr. Smith intimates that it is not beyond possibility that the constitutionality of Maine's water-power law might not stand the test of an appeal to the higher courts, further stating that Maine electricity and West Virginia gas are forms of energy that must enter freely into interstate commerce. He said:

We have three forms of energy: coal, oil and falling water. Maine has a goodly share of one and none of the others. It is well to take this account of stock when we talk about non-export of electric energy. What would freight rates be if the railroads of Maine had not the bituminous coal fields of West Virginia, Maryland and Pennsylvania to furnish motive power? I recall hearing in New England some criticism of Pennsylvania placing a special tax on her anthracite, practically an export tax on the shipments of this favored coal to Maine and other states. I condemn the Pennsylvania anthracite tax almost as much as I condemn the Maine non-transmission law.

Coming Conventions

American Ceramic Society. Ross C. Purdy, Lord Hall, Ohio State University, Columbus, Ohio. Convention at Atlantic City, Feb. 4-8.

American Electrochemical Society. C. G. Fink, Columbia University, New York City. Meeting at Hotel-Bellevue-Stratford, Philadelphia, Pa., April 24-26.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Midwinter convention at the Bellevue-Stratford Hotel, Philadelphia, Feb. 4-8. Spring convention at Birmingham, Ala., April 7-10.

American Institute of Mining and Metallurgical Engineers. F. F. Sharpless, 29 West 39th St., New York City. Annual meeting at New York City, Feb. 18-21.

American Society of Heating & Ventilating Engineers. C. W. Obert, 25 West 39th St., New York City. Annual meeting at New York City, Jan. 22-25.

American Society of Mechanical Engineers, Calvin W. Rice, 29 West 39th St., New York City. Spring meeting at Cleveland, Ohio, May 26-29, formerly announced, May 19-22.

American Water Works Association. J. M. Diven, 153 West 71st St., New York City. Annual convention at New York City, May 19-21.

Engineering Institute of Canada. Fraser S. Keith, 176 Mansfield St., Montreal, Canada. Annual general Meeting at Montreal, Quebec, Jan. 22—Ottawa, Ontario, Jan. 23-24.

Indiana Engineering Society. Charles Brossman, 1503 Merchants Bank Bldg., Indianapolis, Ind. Annual meeting at Lincoln Hotel, Indianapolis, Ind. Feb. 14-15.

Iowa Engineering Society. Blanche Veig, Acting Secretary, 406 Flynn Bldg., Des Moines, Iowa. Annual meeting at Cedar Rapids, Jan. 29-Feb. 1, 1924.

Master Boiler Makers Association. H. D. Vought, 26 Cortlandt St., New York City. Meeting at Chicago, May 20-23, 1924.

National District Heating Association, D. L. Gaskill, 112 West Fourth St., Greenville, Ohio. Annual convention at New York City, June 11-14, 1924.

National Electric Light Association. M. H. Aylesworth, 29 West 39th St. New York City. Annual convention at Atlantic City, Young's Million-Dollar Pier, May 19-24.

National Marine Engineers' Beneficial Association. Geo. A. Grubb, 313 Machinists' Bldg., Washington, D. C. Annual Convention at Franklin Square Hotel, Washington, D. C. Jan. 21-26.

Society of Automotive Engineers, Coker F. Clarkson, 29 West 39th St., New York City. Annual meeting at General Motors Bldg., Detroit, Mich., Jan. 22-25.

Society of Industrial Engineers. George C. Dent, 608 South Dearborn St., Chicago, Ill. Eleventh annual convention at Buffalo, N. Y., April 30 to May 2, 1924.

Personal Mention

J. M. Lee, formerly superintendent of electrical production of the Public Service Company of Northern Illinois, has been appointed construction engineer for the same company.

Frank E. Chase, Tonawanda, N. Y., chief engineer at the municipal pumping station, has been appointed acting superintendent of public works for the municipality.

Herman W. Schroeder has been appointed district auditor of the Southwestern district of the General Electric Co., following the recent creation of this district by that company.

H. W. Brooks has been appointed fuel engineer in charge of the section on efficient use of fuels, in the Department of the Interior, with headquarters at the Bureau of Mines experiment station at Pittsburgh, Pa.

Carl Ewald Grunsky, of San Francisco, was elected president of the American Society of Civil Engineers on Jan. 16, at the seventy-first annual meeting of the body. Mr. Grunsky succeeds Charles F. Loweth, of Chicago.

Society Affairs

The Greenville, N. C., Branch of the A.S.M.E. at its Jan. 28 meeting will hear Fred R. Low, president of the A.S.M.E., speak.

The Charlotte, N. C., Branch of the A.S.M.E. will have as speaker at its Jan. 26 meeting Fred R. Low, president of the A.S.M.E.

The Atlanta Section of the A.S.M.E. will hear Fred R. Low, president of the A.S.M.E. and editor of *Power*, speak on "The Engineering Magazine's Value to the Engineer and the Community," at its Jan. 29 meeting.

The New Haven Section of the N.A.S.E. will hear A. Starr, of Brooklyn, N. Y., talk on "Superheat," and J. A. Holland, of New London, Conn., on "The Mercury Boiler Installation of the Hartford Electric Light Co.," at its Jan. 26 meeting.

Trade Catalogs

Tubes, Condenser—The American Brass Co., Waterbury, Conn. Bulletin B2, "Anaconda Condenser Tubes," contains discussions with specifications in regard to these condenser tubes. Leaflet, "Anaconda Condenser Tubes in the Power Plant."

Pulverizers—Fuller-Lehigh Co., Fullerton, Pa. Catalog, "Fuller-Lehigh Equipment for Producing Pulverized Material," illustrates and describes mills, pulverizers, driers, crushers, burners, conveying systems and other equipment.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Jan. 7, 1924	Jan. 14, 1924
Pool 1	New York	$3.25	$3.25
Smokeless	Columbus	2.00	2.00
Clearfield	Boston	2.25	2.25
Somerset	Boston	2.50	2.50
Kanawha	Columbus	1.75	1.75
Hocking	Columbus	2.00	2.00
Pittsburgh No. 8	Cleveland	2.00	1.90
Franklin, Ill.	Chicago	2.50	2.50
Central, Ill.	Chicago	2.25	2.25
Ind. 4th Vein	Chicago	2.75	2.75
West Ky.	Louisville	1.75	1.75
S. E. Ky.	Louisville	1.90	1.90
Big Seam	Birmingham	2.15	2.15

FUEL OIL

New York—Jan. 17, light oil, tank-car lots, 28@34 deg. Baumé, 4½c. per gal., 36@40 deg. 5½c. per gal., f.o.b. Bayonne, N. J.

St. Louis—Jan. 8, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.75@$1.80 per bbl.; 26@28 deg., $1.80@$1.85; 28@30 deg., $1.85@$1.90; 32@36 deg., gas oil, $2@$2.05 per bbl.; 36@40 deg., distillate, $2.15@$2.25 per bbl.

Pittsburgh—Jan. 9, f.o.b. local refinery, 30@34 deg., fuel oil, 5c. per gal.; 36@40 deg., fuel oil, 5½c.; 34 deg., neutral 8½c. per gal.

Dallas—Jan, 11, f.o.b. local refinery, 26@30 deg., $1.30 per bbl.

Cincinnati—Jan. 15, tank-car lots, f.o.b. local refinery, 26@30 deg. Baumé, 4⅜c. per gal.; 30@32 deg., 5¼c.; 38@42 deg., distillate, 6c. per gal.

Philadelphia—Jan. 11, 28@30 deg., $1.78½@$1.82 7/10 per bbl.; 18@22 deg., $1.62½@$1.66 7/10; 13@16 deg., $1.47@$1.51 7/10 per bbl.

Boston—Jan. 1, tank-car lots, f.o.b. heavy oil, 12@14 deg. Baumé, 4½c. per gal.; light oil, 28@32 deg. Baumé, 6½c. per gal.

Chicago—Jan. 8, 24@26 deg., $2.12 per bbl.; gas oil, 32@36 deg., 4.93c. per gal.

New Plant Construction

Ala., Montgomery—The Atlantic Coast Line Railway Co., Wilmington, N. C., plans for the construction of a steam power house at its proposed local repair shops, estimated to cost $100,000, for which bids have been called on a general contract.

Ark., Little Rock—The Monarch Mill & Lumber Co., has tentative plans for the rebuilding of its power house, recently destroyed by fire. Additional equipment will be installed.

B. C., Chemanius—The Victoria Lumber & Mfg. Co., Victoria, B. C., plans for the construction of a power plant at its proposed local lumber mill, estimated to cost $7,500,000. It will replace a plant destroyed by fire several months ago. All lumber and woodworking machinery will be electrically-operated. E. J. Palmer is general manager.

Calif., Fresno—The San Joaquin Light & Power Corporation is arranging a fund of about $500,000, for extensions and improvements in existing steam and hydro-electric power plants during the present year. An expansion program in the same period, including additional generating plants, lines, etc., is estimated to involve $6,000,000.

Calif., San Francisco—The Bureau of Supplies and Accounts, Navy Department, Washington, D. C., will take bids until Feb. 5, for power plant equipment for the Mare Island navy yard, as set forth in Schedule 1788.

Calif., San Francisco—The Lyons California Glace Fruit Co., 535 Folsom Street, plans for the construction of a steam power house at its proposed plant at Mariposa and Alabama Avenues, estimated to cost $250,000. George Wagner, 251 Kearny Street, is architect and contractor.

Del., Middletown—The Light and Water Board will commence enlargements in the municipal electric plant and will install additional equipment, including pumps, air compressor, etc.

D. C., Washington—The Bureau of Supplies and Accounts, Navy Departments, will take bids until Feb. 5, for 2,666 boiler tube brushes for the San Diego, Calif., naval station; for 530 boiler tube brushes and 2,700 steel brushes for the Mare Island, Calif., navy yard; for 7 tube cleaners for the Boston navy yard; and 9 tube cleaners for Mare Island, all as set forth in Schedule 1759.

D. C., Washington—The general purchasing officer, Panama Canal, will take bids until Feb. 1, for a quantity of boiler tubes, valves, unions, iron and steel pipe, and other miscellaneous materials, as specified in Circular 1584.

D. C., Washington—The chief of engineers, United States Army, 2825 Munitions Building, will take bids until 11 a.m., Jan. 28, for motor-driven ventilating sets, consisting of 9 blowers, 2 propeller fans, and 4 speed blowers, motor-driven.

Fla., Fort Pierce—The Gulf Refining Co., Frick Annex, Pittsburgh, Pa., is considering the installation of a pumping plant at its proposed local oil storage and distributing works, estimated to cost about $85,000.

Fla., Jacksonville—The Cheek-Neal Coffee Co., will build a power house at its proposed five-story coffee factory and can-manufacturing plant on local site, estimated to cost $300,000, for which plans will soon be prepared.

Fla., Jasper—The Thorn-Reed Lumber Co., has tentative plans for the erection of a power house at its proposed local mill, to double the present plant output. It is estimated to cost in excess of $80,000. John Thorn is general manager.

Fla., Lakeland—The Burns Development Co., Spencer-Futch Building, is planning for the purchase of about 350 water pumps, automatic type, with capacity of 450 g.p.h.

Ga., Columbus—The Columbus Electric & Power Co., has preliminary plans under advisement for the construction of a hydro-electric generating plant near the Goat Rock dam, about 15 miles from the city, estimated to cost $5,000,000. R. M. Harding is manager.

Ga., Savannah—The Central of Georgia Railway Co., has tentative plans under advisement for the construction of a power house at its proposed local car repair shops, estimated to cost $300,000, replacing works destroyed by fire several months ago. C. K. Lawrence is chief engineer.

Ga., Silver Creek—The American Chemical Co., is considering the construction of a power house at its proposed local plant, estimated to cost $100,000. Joel Perkinson, Chattanooga, Tenn., is in charge of the project.

Ill., Chicago—The Chicago Asbestos Table Mat Co., 215 Loomis Street, will build a one-story boiler plant at its proposed works on Irving Park Boulevard, near California Street, 100 x 125 ft., estimated to cost $80,000, for which bids are being asked on general contract. Clarence Hatzfeld, 7 South Dearborn Street, is architect.

Ill., Chicago—The Nelson-Wiggins Piano Co., 224 Sheldon Street, will build a power house at its proposed four-story plant at 1731 Belmont Avenue, estimated to cost $250,000. Fred V. Prather, 400 North Michigan Avenue, is architect.

Ind., Peru—The Wabash Railroad Co., St. Louis, Mo., is planning for the construction of a power house at its proposed division repair shops on site acquired near the city limits, estimated to cost in excess of $700,000.

Ind., Richmond—The City Council will build a steam power house at its proposed municipal market and auditorium, estimated to cost $250,000. Werking & Son, American Trust & Savings Building, are architects.

Ind., St. Paul—John A. Shafer, Odd Fellows Building, Indianapolis, engineer, representing a company now said to be in process of organization, has plans under way for the construction of a hydro-electric power plant on the Flat Rock River, near St. Paul, estimated to cost $500,000. It is expected to take bids at an early date.

Iowa, Bedford—The Bedford Power Co., has plans in progress for a new power plant on local site, with ice-manufacturing and cold storage plant adjoining, estimated to cost $200,000, with equipment. The Prince-Nixon Engineering Co., Peters Trust Building, Omaha, Neb., is structural engineer.

Iowa, Grimes—The Grimes Canning Co., plans for the construction of a power house at its proposed two-story plant, estimated to cost $150,000. W. J. Stewart is president.

Iowa, Oelwein—The City Council, C. D. Shippy, city clerk, will receive bids until Feb. 5, for a pumping plant and equipment, in connection with extensions to the municipal waterworks, for which bids will be taken at the same time. Edward B. Tourtellot, Oelwein, is engineer.

Ky., Louisville—The Ford Motor Co., Highland Park, Detroit, Mich., will build a one-story power house at its local assembling plant, on site lately acquired, for which bids will soon be called. It will cost close to $1,000,000 with equipment. Albert Kahn, 1000 Marquette Building, Detroit, is architect.

La., Melville—The City Council will receive bids until Jan. 29, for equipment for a municipal waterworks, including two crude oil engines, direct-connected to electric alternators; motor-driven service and fire pumps; electric switchboard, instruments, etc.; and 50,000-gal. steel water tank and tower. Swanson-McGraw, Inc., United Fruit Building, New Orleans, La., is engineer.

La., Shreveport—The Ideal Laundry & Dry Cleaning Co., 1019 Travis Street, is planning for the purchase of a steam

superheater, switchboard and other equipment for installation at its plant.

Md., Baltimore—The Anthracite Fuel Corporation, 706 Continental Building, plans for the construction of a power house at its proposed briquette manufacturing plant in Eighth Street, for which foundations are in progress, estimated to cost $200,000. F. A. Weymouth is president.

Md., Hancock—The Board of Commissioners is planning for the installation of centrifugal pumping machinery in connection with waterworks enlargements.

Mich., Flint—The Buick Motor Car Co., will make extensions in its steam and electric plants in connection with the construction of a number of new manufacturing additions, estimated to cost close to $10,000,000. Plans will be prepared at once.

Minn., Duluth—The Minnesota Light & Power Co., is developing plans for the construction of two steam-operated generating stations at Cloquet and Scanlon, Minn., during the present year; also, for a hydro-electric power plant in the Vermilion Lake district, near Ely, Minn. The work will be carried out in connection with an improvement and extension program estimated to involve $15,000,000. W. S. Robertson is vice-president and general manager.

Minn., Minneapolis—The Fulton Bag & Cotton Mills, Inc., Atlanta, Ga., plan for the construction of a power house at its proposed local mills, estimated to cost in excess of $650,000. Frederick Kees, 246 Plymouth Building, Minneapolis, is architect.

Minn., St. Paul—The Board of Trustees, Macalester College, Grand and Macalester Avenues, will take bids early in April for the construction of a power house at the institution, estimated to cost $50,000. W. M. Ingeman, 637 Endicott Building, is architect. Richard W. Jones is acting president.

Minn., Willmar—The Common Council plans for the installation of an electric-operated pumping plant in connection with a waterworks system, estimated to cost $150,000. Toltz, King & Day, Inc., Pioneer Building, St. Paul, Minn., is engineer. A project is also in contemplation for a municipal power plant to cost approximately $100,000.

Mo., Ava—The Common Council is taking bids until Jan. 24, for deep-well pumping equipment, water tower, tank and auxiliary apparatus for a new waterworks. J. E. Curry is town clerk. Bonds for $35,000 have been approved.

Mo., Humansville—The Sac River Light & Power Company is perfecting plans for extensions in its plant, including the installation of additional equipment.

Mo., Norborne—The Common Council has tentative plans for the purchase of the local power plant, operated by the Norborne Fuel, Ice & Light Co., for municipal property. Improvements will be made, including equipment additions.

Mo., Taskee Station—H. E. Springer and I. W. Rogers, both of Poplar Bluff, Mo., have tentative plans for the construction of a power house at their proposed local ore concentrating plant, to cost close to $200,000.

N. J., Camden—The Joseph Campbell Co., manufacturer of canned soups, etc., is considering the construction of a power house at its proposed plant addition, estimated to cost $700,000.

N. J., Park Ridge—The Common Council will call for bids early in Feb. for the installation of two pumping plants, standpipe and other equipment for the municipal waterworks. H. J. Harder, 129 Market Street, Paterson, N. J., is engineer.

N. J., Perth Amboy—The National Fireproofing Co., Fulton Building, Pittsburgh, Pa., will construct a power house at its proposed local hollow tile manufacturing plant, to replace a works lately destroyed by fire. It will cost close to $350,000, with equipment. Sidney F. Heckert, Bessemer Building, Pittsburgh, is architect.

N. J., Trenton—The Thomas Maddock's Sons Co., Perry Street, manufacturer of sanitary ware, plans for the construction of a power house at its proposed pottery at Hutchinsons Mills, Hamilton Township, where site recently has been purchased. No time has as yet been set for commencing the project. A. M. Maddock is president.

N. Y., Brooklyn—Thomas A. Digan, Inc., 656 Third Avenue, steamship supplies, has filed plans for the construction of a two-story and basement cold storage plant, 50 x 100 ft., for which David M. Ach, 1 Madison Avenue, New York, is architect.

N. Y., Hamburg—The Common Council plans for the construction of an electric-operated pumping plant at the proposed municipal sewerage works, estimated to cost $350,000. George C. Diehl, county engineer, will prepare plans.

N. Y., Long Island City—I. Miller & Sons, Inc., Fifth Avenue and Forty-sixth Street, New York, plan for the installation of a boiler plant in its proposed six-story shoe factory on local site, estimated to cost $500,000, for which plans will soon be drawn.

N. Y., New York—The Board of Trustees, Roosevelt Hospital, Inc., 428 West Fifty-ninth Street, will commence the construction of a one-story steam power house at the institution, 70 x 90 ft., to cost about $140,000, with equipment. York & Sawyer, 100 East Forty-second Street, are architects.

N. Y., Watertown—The St. Regis Paper Co., plans for the construction of a power plant at its proposed paper and pulp mill on site selected at St. Augustin, near Quebec, estimated to cost close to $300,000.

N. C., Charlotte—The Ford Motor Co., Highland Park, Detroit, Mich., will build a power house at its proposed local assembling plant on site recently acquired, to cost in excess of $250,000. Albert Kahn, 1000 Marquette Building, Detroit, is architect.

N. C., New Bern—The Consumers' Ice Co. is making inquiries for equipment for its local plant, and will purchase a 50-ton ice-making machine, steam-operated, and auxiliary apparatus.

Ohio, Youngstown—David Joseph has had plans completed for the erection of a steam power house on Andrews Avenue, one-story, 50 x 180 ft., estimated to cost about $45,000, with equipment.

Okla., Chickasha—The City Council plans for the installation of electric-operated pumping machinery in connection with a sewerage disposal works, for which bonds for $70,000, have been voted. J. C. Milliken is engineer.

Ore., North Bend—The Mountain States Power Co., Albany, Ore., has plans in progress for the construction of a power plant on the local waterfront, with initial capacity of 5,000 kw., estimated to cost $650,000, with equipment.

Pa., Easton—The Pennsylvania Edison Co., is perfecting plans for active construction of its proposed hydro-electric generating plant on the Delaware River, near Riegelsville, Pa., early in the spring. It will cost close to $3,000,000.

Pa., Harrisburg—The Air Reduction Sales Co., 342 Madison Avenue, New York, is reported to be planning for the erection of a new local plant and power house, to cost in excess of $200,000, for the production of industrial oxygen and kindred products.

Pa., Lewistown—The Pennsylvania Wire Glass Co., Pennsylvania Building, Philadelphia, will build a power house at its proposed local plant, for which plans have been under way for several months and now about to mature; it is expected to ask for bids in Feb. The works will cost approximately $500,000. Frank W. Hayes, company address, is architect.

Pa., New Castle—The Blair Strip Steel Co., recently organized, plans for the construction of a power house at its proposed local mill, estimated to cost in excess of $85,000. George D. Blair, Sr., heads the company.

Pa., Philadelphia—The Ford Motor Co., Highland Park, Detroit, Mich., will construct a power house at its new local assembling plant on Sixty-third Street, to cost in excess of $400,000, for which bids have been called on a general contract. Albert Kahn, 1000 Marquette Building, Detroit, is architect.

Pa., Phillipsburg—The Board of Trustees, State Hospital, is taking bids until Jan. 25, for the construction of a power house and mechanical laundry plant at the institution. George S. Idell, 1705 Chestnut Street, Philadelphia, Pa., is architect, in charge.

Tenn., Cleveland—The Cleveland Woolen Mills, Inc., has authorized plans for the construction of a steam-electric power plant at its local mills, with installation of 500 kw. generator and auxiliary equipment, estimated to cost $50,000. H. B. Moore, vice-president, will be in charge of equipment purchases. W. H. Sears, Chattanooga, Tenn., is architect.

Tenn., Columbia—The Southern Cities Power Co., Chattanooga, Tenn., will make extensions and improvements in its local hydro-electric generating plant, including remodeling of present station and installation of equipment.

Tenn., Knoxville—The Burdett Oxygen Co., Chattanooga, Tenn., plans for the construction of a power house at its proposed local plant for the manufacture of industrial oxygen products, estimated to cost $100,000. E. A. Faulhaber is vice-president.

Tenn., Knoxville—J. L. Humphreys has tentative plans for the installation of an ice and refrigerating plant and system at his proposed market building on site selected at North Knoxville, estimated to cost $175,000.

Tenn., Memphis—The Ford Motor Co., Highland Park, Detroit, Mich., will build a power house at its proposed local assembling plant, for which bids are being taken on a general contract. It will cost more than $400,000. Albert Kahn, 1000 Marquette Building, Detroit, is architect.

Tenn., Nashville—The Tennessee Enamel Mfg. Co., Park Avenue, is planning for the installation of air compressors, motors, belting and other power equipment in connection with the rebuilding of its plant, recently destroyed by fire, estimated to cost $70,000. M. H. Wright is president.

Tex., Austin—The Consumers' Ice Co., plans for the installation of additional electric-operated equipment at its ice-manufacturing plant on Fourth Street. Walter Bremond, Jr., is president.

Tex., Beaumont—The Southwestern Gas & Electric Co., has arranged a fund of about $200,000, for extensions and improvements in its local plant, including the installation of considerable additional equipment.

Tex., Bishop—The Farmers' Gin & Ice Co., is planning for the installation of a Corliss engine at its plant, with auxiliary power equipment. T. E. Burney is manager.

Tex., Colorado—The Continental Cotton Oil Co., has plans under way for the rebuilding of the portion of its mill and power house, recently destroyed by fire with loss reported at $75,000. John Guitar, Abilene, Tex., is president.

Tex., Dallas—The Board of Water Commissioners is planning for the installation of a turbine pumping unit at the Oak Cliff waterworks station to increase the output to about 2 m.g.d.

Tex., Kaufman—The Big State Oil Co., Dallas, Tex., has secured state permission to construct and operate a hydro-electric power plant on Cedar Creek, near Kaufman.

Tex., San Antonio—The San Antonio Public Service Co., has tentative plans for extensions and improvements in its local power plant, to be carried out in connection with a general betterment program during the present year. The estimated cost of the station expansion is estimated at $400,000, including line work.

Tex., Texarkana—The Southern Ice & Utilities Co., plans for extensions in its electric power and ice-manufacturing plants to cost in excess of $200,000, including equipment.

Va., Norfolk—The Virginia Railway & Power Co., has preliminary plans for extensions in its steam-operated generating plant to cost about $450,000, to include the installation of an additional generator and auxiliary equipment, underfeed stokers and other boiler room apparatus.

Va., Portsmouth—The Southern Wheel Co., Olive Street, St. Louis, Mo., plans for the construction of a power house at its proposed local plant for the manufacture of car wheels, to cost close to $100,000.

Va., Suffolk—The Planters' Nut & Chocolate Co., plans for the construction of a power house at its proposed local plant, six-story, 100 x 320 ft., estimated to cost $375,000. A site has been secured on Culloden Street.

Wash., Seattle—The Bureau of Supplies and Accounts, Navy Department, Washington, D. C., will take bids until Jan. 29, for 72 mechanical thermometers for the Puget Sound navy yard, as specified in Schedule 1754.

Wash., Wenatchee—The City Council plans for the installation of an electric-operated pumping plant, in connection with waterworks extensions to cost approximately $60,000.

Wis., Phillips—The Common Council, Carl F. Scheel, city clerk, will receive bids until Feb. 1, for one centrifugal pump, 300 g.p.m., with motor-driven auto float switch control; one centrifugal pump, 1250 g.p.m., motor-driven fitted, with pulley for oil engine; one 150 hp. oil engine; and one 100,000 gal. tank on 90 ft. tower. Frank Henry, Phillips, is engineer.